PROCESS DESIGN
FOR
VILLAGE OF SAUGET, ILLINOIS
CHEMICAL TREATMENT FACILITY
JULY 21, 1972

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Monsanto
Enviro-Chem
Systems Inc.

VS0547

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DESIGN BASIS AND PROJECT TONE

Process Selection

The treatment process has been designed based on the results of the engineering study and preliminary process design done by Monsanto Enviro-Chem and submitted to the Village of Sauget in a report dated 5/15/72. The design information for the recommended unit operations has been shown in Appendix A. Any modifications which have been made because of changes in the type of lime, expected changes in waste composition, or use of existing or modified equipment will be shown on the equipment specification sheets.

System Reliability and Treatment of Storm Water

The Illinois Pollution Control Board Rules and Regulations on System Reliability are listed below:

Part VI. Performance Criteria

This part contains specific requirements and prohibitions concerning existing and potential sources of water pollution.

601 Systems Reliability

(a) Malfunctions. All treatment works and associated facilities shall be so constructed and operated as to minimize violations of applicable standards during such contingencies as flooding, adverse weather, power failure, equipment failure, or maintenance, through such measures as multiple units, holding tanks, duplicate power sources, or such other measures as may be appropriate.

(b) Spills. All reasonable measures, including where appropriate the provision of catchment areas, relief vessels, or entrapment dikes, shall be taken to prevent any spillage of contaminants from causing water pollution.

602 Combined Sewers and Treatment Plant Bypasses

(a) The installation of new combined sewers is prohibited, except where sufficient retention or treatment capacity is provided to ensure that no violation of the effluent standards in Part IV of this Chapter occurs.

(b) Excess infiltration into sewers shall be eliminated, and the maximum practicable flow shall be conveyed to treatment facilities. Overflows from sanitary sewers are expressly prohibited.

(c) All combined sewer overflows and treatment plant bypasses shall be given sufficient treatment to prevent pollution or the violation of applicable water quality standards. Sufficient treatment shall consist of the following:

(1) All dry weather flows, and the first flush of storm flows as determined by the Agency, shall meet the applicable effluent standards;

(2) Additional flows, as determined by the Agency but not less than ten times the average dry weather flow for the design year, shall receive a minimum of primary treatment and disinfection with adequate retention time;

(3) Additional treatment, through retention and return of excess flows to the treatment plant or otherwise, shall be provided when required to achieve compliance with water quality standards.

(d) Compliance with paragraph (c) of this Rule 602 shall be achieved on or before the following dates:

(1) All treatment plant bypasses, by the applicable date for improvement of treatment works under Part IV of this Chapter;

(2) All combined sewer overflows within the Metropolitan Sanitary District of Greater Chicago, by December 31, 1977;

(3) All other combined sewer overflows, by December 31, 1975.

To meet the criteria under 601:

(1) Multiple units and spares will be purchased and installed where required for system reliability. (i.e., installed spare pump for influent, bypass line for influent line when orifice or flow control valve being repaired, three cells in the neutralization basins with allowance for shutdown of any cell without plant shutdown, installed spare pump in lime slurry line, design of duplicate clarifiers and flocculation basins allows continued plant operation in case of shutdown of one chamber, installed spare pump in effluent recycle line, pumping station piping designed to allow three storm pumps to pump plant effluent to river in case of failure of Corps of Engineer's [illegible] station, two lime storage silos, and two feeder-slaker groups to allow shutdown of one unit for repairs while still continuing operation of lime treatment facility, installed spare sludge pump, 375,000 gallon emergency asphalt-lined storage lagoon for scum and sludge, operation of vacuum filters for 16 hours/day to allow for equipment repairs, 15 hours sludge holding capacity in the clarifiers, an installed spare pump on the polyelectrolyte feed line.)

2. Installation of a 1.1 MGD storage lagoon will allow for up to 3 hours of total plant shutdown without any bypass of wastewaters.

3. Because no power failures have caused interruption of the operation of the existing Sauget Treatment Plant during the last five years and the high costs for auxiliary power source, no auxiliary power source will be provided.

To meet the criteria under 602:

(1) A "first flush" holding capacity of 800,000+ gallons has been installed. Calculations for the "first flush" of storm water have been shown in Appendix B.

(2) It is not felt that there will be any need for "additional treatment" of excess storm waters beyond the clarification provided in a clarifier with an overflow rate of 2000 gal/day-ft^2.

The design flow rate has been based on predicted flow levels for 1974 as supplied to Enviro-Chem by the Village of Sauget. (See Dwg 3-)

In Appendix C are shown calculations for plant capacity on preliminary flow numbers. It was assumed in these preliminary calculations that the storage lagoon would be drained at a maximum rate of 280 gpm. Final design will allow draining rates of greater than 5000 gpm. It was shown that a design capacity of 10.1 MGD would allow handling all normal dry weather flow more than 98% of the time. This is approximately equal to two standard deviations above the mean. The possibility does exist that the 10.1 MGD plant would have over 1 MGD excess capacity if peak flows predicted did not coincide.

If other industry requiring waste water treatment should locate in the Sauget area, several possible alternatives will be open if enough capacity is not present in the proposed chemical treatment facility.

The first option would be to expand the storage lagoon so as to allow greater reserve capacity.

The second option would be to store surges in the plants or to require limited discharges for new industry during periods of the day when peak flows have been observed.

The Village has decided to install 15% excess flow capacity into the system which is equivalent to a design flow of 11.5 MGD. This safety factor plus the change in the draining rate for the storage lagoon should increase the system reliability for dry weather flow to a level approaching 100%.

From the information shown on Dw. 6 on acidities, we recommend that the lime neutralization facility be designed to deliver as a maximum enough lime to neutralize 391,300 lbs/day of acidity and on the average sufficient lime to neutralize 75,300 lbs/day of acidity.

With this design basis, neutralization will be possible 100% of the time barring equipment failure, power failures, non-delivery of lime, or disaster.

Because sludge generation rates are the least reliable data from the pilot plant study, and questions have been posed as to actual lime utilization, sludge handling capacity will be based on lime usage for the predicted 1974 average acidity with a 30% safety factor.

Provisions for Future Expansions or Additions

To provide for expansion of the planned treatment operations, units will be so arranged as to allow installation of duplicate units, (i.e., one additional clarifier to handle 5-6 MGD, an additional vacuum filter, an additional sludge pump, additional neutralization chambers.)

To provide for possible future treatment operations, units will be so arranged as to allow installation of possible treatment steps after the chemical system.

Plant Appearance

Basic appearance of facility will not be altered. Design does not include any considerations for upgrading the area or installing equipment in such a manner to make the plant a "showplace."

GENERAL PROCESS DESCRIPTION

Influent Wet Well (V-001)

The influent wet well is part of the existing pumping station which will act as a wet sump for the influent pump and two of the five storm water pumps. Waste water will continue to enter the influent wet well by four existing Village of Sauget sewers. Waste will pass through the bar screens (Z-001 thru Z-003) and under the floating scum collector (Z-004) to the influent and storm water pumps. The wet well bottom is approximately at EL385, the wall top at EL411 and the working water depth of EL393 to EL395. The influent wet well retention time will be approximately 10 minutes at 6,000 GPM. The maximum inlet flow to this well will be approximately 60,000 GPM.

Bar Screens and Trash Rake (Z-001, Z-002, Z-003, and Z-028)

The existing vertical bar screens are of wooden construction and located in the influent wet well (V-001). The bar screens are inclined 8° from vertical in three six foot wide sections with maximum space between bars of 2". The bar screens are to prevent trash and debris exceeding 2" diameter from passing through the influent wet well and into the influent or storm water pumps and thereby causing pump damage. The trash accumulating on the bar screens will be removed by the existing trash rake (Z-028).

<u>Floating Scum Skimmer</u> (Z-004)

The floating scum skimmer will be located in the influent wet well (V-001). The slotted 10" fiberglass reinforced pipe is to be hand operated to remove floating scum, grease, and oil from the influent wet well and discharge them through a flexible connecting line to the scum tank (V-005) located in the influent dry well (V-002).

<u>Pumping Station Scum Handling</u> (P-007, V-013, and V-052)

Scum, oil, grease, and waste water from Z-004 and V-005 will be pumped to the scum decanting tank (V-013). The scum and water will separate in V-013 and will then be decanted through the scum decanting manhole (V-052) with the water being returned to the influent wet well (V-001) and the scum discharged for disposal by the Village of Sauget.

Influent and Storm Water Pumps In V-002 (P-001, P-002, and P-003)

The influent and storm water pumps are existing Fairbanks - Morse Figure 5710 acid resistant bronze pumps with 100 horsepower drive motors. All three pumps have a design capacity of 10,000 GPM. The influent pump will discharge through a butterfly flow control valve (maximum flow rate is 8,000 GPM) and flow measurement orifice to the influent surge chamber (V-008), raising the influent water to the treatment plant to a level sufficient to maintain gravity flow through the rest of the system (i.e., main flow). The storm water pumps will discharge through a force main to the storm water storage lagoon (V-011) or storm water clarifier (V-012). P-002 will also act as an installed spare for P-001 through an appropriately valved manifold. P-001 will be controlled by a flow control valve with a low level shut off. P-002 and P-003 will be controlled by sump level controls. The lagoon force main shall also be supplied with a by-pass line to the existing storm water surge chamber (V-010) in the event it should be necessary to pump directly to the Mississippi River.

Storm Water Wet Well and Effluent Wet Well (V-003 and V-014)

The storm water wet well and effluent wet well will be formed by a new dividing wall to be constructed in the existing effluent wet well. The storm water wet well shall be a wet sump for three existing storm water pumps (P-004, 005, and 006). Excess storm flow from the influent wet well (V-001) will be pumped from V-003 to the storm water storage lagoon (V-011) or storm water clarifier (V-012). The effluent wet well (V-014) will be a channel which leads directly to the final Village outfall. Treated effluent and clarified, excess storm flows will pass through this sump to the Corps of Engineers Pumping Station and thence to the Mississippi River.

Storm Water Pumps (P-004, P-005, and P-006)

The three storm water pumps, located in the storm water dry well (V-004) are existing Fairbanks - Morse acid resisting bronze Figure 5710 centrifugal pumps with a pumping capacity of 10,000 GPM each.

Influent Surge Chamber (V-008)

The influent surge chamber will receive flow from the influent pump (P-001) and will subsequently discharge by gravity into the aerated grit chamber (V-009).

Storm Water Storage Lagoon (V-011)

The storm water storage lagoon will be a clay lined earthen lagoon with overall dimensions of 168' by 168'. It will provide 1.1 million gallons working storage volume for storage (and subsequent treatment) of first-flush storm water flows and process surges above the design flow rate (8,000 GPM).

Storm Water Clarifier (V-012)

Excess storm water flows (i.e., flows above plant design flow rate after first flush volume storage) will be discharged to the storm water clarifier, a rectangular straight-line, clay-lined, earthen clarifier. The clarifier will have a design overflow rate of 2,000 gallons per square foot per day at the design flow rate of 50,000 GPM. The clarifier will have overall dimensions of 298' by 184', and be equiped with an inlet distribution weir, an effluent weir (Z-034), a scum baffle, and a hand operated scum collector (Z-036). Sludge will be removed from the clarifier by draining and mechanical removal (i.e., bulldozer, drag line, etc.) at appropriate intervals.

Aerated Grit Chamber (V-009)

The aerated grit chamber will remove larger, rapid settling particles from the waste water before lime addition in V-015. The grit collected in the aerated grit chamber will be removed from the chamber by air lift pumps to the decanting chamber and dewatering lift screw (Z-007) from which it will be discharged for disposal by the Village of Sauget. The grit chamber and air lift pumps will be supplied air by the grit chamber blower (C-001).

Lime Storage and Addition (V-016, V-017, V-018, V-019, Z-011, Z-012, Z-013, Z-014, P-011, P-012, and A-005)

Dolomitic pebble quicklime, delivered in hopper trucks, will be unloaded pneumatically and stored in the lime storage silos (V-016 and V-017). Dust generated during truck unloading will be captured by the dust collector (V-019) and returned to a storage silo. The dolomitic lime will be discharged from the storage silos at a preset, controlled rate, to the lime slakers (Z-011 and Z-012) by gravimetric belt feeders (Z-013 and Z-014). The lime will be slaked (by slurrying with effluent recycle water) in the lime slakers. Each slaker-feeder group will be controlled (off-on) by level controls in the milk of lime storage tank (V-018). The 10% milk of lime slurry produced in the slakers will be degritted in the slakers (grit to disposal by the Village of Sauget) and discharged to the milk of lime storage tank. The 10% milk of lime slurry will be stored in the agitated (A-005) milk of lime storage tank (V-018) from which it will be pumped (P-011 and P-012) to the neutralization chambers.

Neutralization (V-015)

The waste flow will have the aerated grit chamber (V-009) by open channel flow and enter three neutralization cells in series. Each cell will provide 15 minutes retention time at a flow rate of 11.5 MGD. The waste will be neutralized by the addition of milk of lime prepared by slaking dolomitic pebble quicklime. A feedback control loop will be used to adjust and control the effluent pH within a range from 8.0 to 8.5 for the dual purposes of reducing acidity and precipitating heavy metals.

Flow Splitter (V-023)

Subsequent to neutralization, the waste will flow through an open channel to a splitter box (V-023). The flow will divide into two equal portions and flow to rapid mix chambers V-024 and V-027 by open channel flow. Downstream of the splitter box the process is divided into two chains.

Rapid Mix

To achieve adequate suspended solids removal a polyelectrolyte (Atlas 2A2) will be added to the neutralized waste. In order to achieve proper mixing of waste flow and polyelectrolyte, two rapid mix chambers (V-024 and V-027) will be provided with one agitator in each chamber (A-008 and A-012). The minimum rapid mix retention time will be 30 seconds.

Flocculation

The effluent of each rapid mix chamber is divided into two equal portions. Each portion then enters a flocculation chamber with a minimum retention time of 20 minutes. Four flocculation chambers will be provided (V-025, V-029, V-034, and V-038).

Agglomeration of suspended solids will be accomplished with paddle-type flocculator agitators, (A-009, A-010, A-011, and A-013 through A-021) arranged for longitudinal tapered mixing.

Chain type rakes, (Z-009, Z-017, Z-022, and Z-029) within the flocculation chamber will be located to remove suspended solids that settle to the bottom. These solids will be raked into the clarifier sludge hoppers. On the return run, these rakes act as scum skimmers. The scum will then be removed from the flocculation chambers by scum collectors Z-018, Z-023, Z-026, and Z-027.

Clarification

The effluents of the flocculation chambers will flow directly into two clarifiers (V-026 and V-030) with a maximum clarifier overflow rate of 500 gpd/ft^2. Each clarifier will be equipped with a traveling bridge type sludge rake (Z-020 and Z-025). Flocculated suspended solids will be separated from the neutralized waste water by gravity sedimentation and then raked to sludge hoppers at the upstream end of the clarifiers. These solids along with the settleable solids raked from the flocculation chambers will be pumped to the sludge handling facilities described in a separate section.

The clarified supernatant will be collected and transported by clarifier effluent structures Z-032 and Z-033 to the existing effluent manhole V-032.

Effluent Recycle

The effluent from manhole V-032 will flow by gravity through two 42" pipes to effluent manhole V-033 which will be modified to act as a sump for effluent recycle pumps P-019 and P-020. A portion of the effluent will be recycled to Z-011 and Z-012 for lime slaking, to Z-007 for grit washing, to F-001 and F-002 for removal of solids from vacuum filter media, and to Z-016 and Z-021 for mixing with concentrated polyelectrolyte solution.

Effluent Manhole (V-035)

Effluent Manhole V-035 will be modified to serve as a junction manhole for treated effluent flow through a 42" pipe from manhole V-033 and storm water flow through a 60" pipe from the storm water parshall flume V-040. This combined flow then will flow by gravity through two 42" pipes to the effluent water wet well V-014 and then by gravity to the Corps of Engineers pumping station.

Sludge Handling

The sludge will be pumped by sludge pumps (P-017 and P-018) from the clarifier to a sludge storage tank (V-045) in the sludge dewatering building (V-046). The sludge will flow from this tank to the vacuum filters (F-001 and F-002) by gravity. The rotary, cloth-medium filters will accomplish the dewatering operation by means of a differential pressure supplied by the vacuum pumps (P-026 and P-027). The de-watered sludge will be discharged from the building (V-046) by means of a belt conveyor (Z-031) and will subsequently be disposed of by the Village of Sauget.

The filtrate and air will discharge to a receiver (V-047 and V-048) which will separate the filtrate from the air. The filtrate will be pumped by two filtrate pumps to the building floor sump (V-051) from which the filtrate will flow by gravity to the influent wet well (V-001).

The air will be discharged to the atmosphere through a water trap silencer supplied with the water ring compressor vacuum pumps (P-026 and P-027). Seal water for the vacuum pumps and water for the polyelectrolyte makeup will be supplied from a seal water sump (V-050) and pumps (P-028 and P-029). City water will provide makeup water for the seal water sump.

REPORT

SOILS AND FOUNDATION INVESTIGATION
PROPOSED WASTE TREATMENT PLANT
SAUGET, ILLINOIS

FOR THE

VILLAGE OF SAUGET

7666-002-07

ATLANTA NEW YORK
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SALT LAKE CITY

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July 20, 1972

Monsanto Enviro-Chem Systems, Inc.
10 South Riverside Plaza
Chicago, Illinois 60606

Attention: Mr. Jerry L. Jones
Engineering Services Manager

Gentlemen:

This letter transmits five copies of our "Report, Soils and Foundation Investigation, Proposed Waste Treatment Plant, Sauget, Illinois, for the Village of Sauget."

The initial scope of our investigation was planned in collaboration with Mr. Jerry Jones of Monsanto Enviro-Chem Systems, Inc., and was outlined in our proposal dated May 19, 1972. During the course of our investigation the scope of our services was increased, at the request of Mr. Jones, to include the investigation for, laboratory testing of, and analyses of suitable clay borrow material to be used as a lining in the lagoons and the drilling of an additional exploration test boring. A preliminary draft of our report was provided to Mr. Jones for his review and comments prior to this submittal of our final report. Our work was performed under Leonard Construction Company Short Form Subcontract No. Gen 542.

Should you have any comments or questions regarding the contents of this report, subsequent to your review of it, please do not hesitate to contact us.

It has been a pleasure to be of service to the Monsanto Enviro-Chem Systems, Inc. on this project, and we appreciate your continued confidence in our firm.

Yours very truly,

DAMES & MOORE

James B. Thompson

James B. Thompson
Partner

JBT:GRS:kb

REPORT

SOILS AND FOUNDATION INVESTIGATION

PROPOSED WASTE TREATMENT PLANT

SAUGET, ILLINOIS

FOR THE

VILLAGE OF SAUGET

INTRODUCTION AND SCOPE

This report presents the results of our soils and foundation investigation performed at the site of the Proposed Village of Sauget Waste Treatment Plant. The proposed facilities will be an addition to an existing waste treatment plant and pumping station located just south of the end of Mobile Street.

The purposes of our foundation investigation were as follows:

1 - To determine the subsurface soil and ground water conditions within the site to the depths which will be significantly affected by foundations.

2 - To evaluate the effect of existing ground water conditions, and projected changes in the water level on the design and construction of the proposed retention ponds and grit chamber.

3 - To evaluate, by performance of laboratory tests, the physical properties of the various deposits and soil strata which underlie the site that will influence foundation design and construction.

4 - To provide recommendations and data for the design and installation of foundations and the grit chamber. These data and recommendations will include foundation type(s), bearing pressures, the elevation(s) at which foundations should be established, and estimated settlements. Should pile foundations be required for support of the lime silos, recommendations will be provided.

5 - To provide recommendations relative to the design of the dikes and liner for the retention ponds, including suitable construction materials, and recommendations relative to dewatering and cleaning of the ponds.

6 - To perform an investigation for, laboratory testing of, and engineering analyses of suitable clay borrow material to be used as a lining in the lagoons.

7 - To provide recommendations relative to earthwork operations which will be required at the site including stripping, excavating,

dewatering, and the placement and compaction of fill material.

8 - To provide recommendations relative to any unusual design or construction techniques which may be dictated by the subsurface conditions at the site.

The results of our field explorations and laboratory tests, which were used as the basis for our recommendations, are presented in the APPENDIX of this report.

PROPOSED CONSTRUCTION

We were provided with Drawing No. 3-1 entitled "Plot Plan, Wastewater Treatment Systems, Village of Sauget, Illinois" dated May 10, 1972, prepared by Monsanto Enviro-Chem Systems, Inc. Shown on this drawing was the planned layout of each of the proposed structures.

The proposed plant will include the construction of the following new facilities:

1 - Storm Water Bypass Clarifier - This will be a diked retention pond approximately 180 feet by 290 feet in plan dimensions. The dike crest will be established at about elevation* 413 and the bottom of the pond will be at about elevation 400. This lagoon will be filled to approximately elevation 410 with an acidic solution having a pH of 1 or 2.

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*All elevations presented in this report refer to U.S.G.S. Datum.

We understand the lagoon will remain full at all times except when being cleaned. Approximately once every four years the lagoon will be cleaned utilizing conventional construction equipment such as bulldozers, end loaders, etc.

2 - <u>Storm Water Storage Lagoon</u> - This will also be a diked retention pond and will have plan dimensions of approximately 180 feet by 180 feet. The dike crest and pond bottom will be established at approximately elevations 413 and 400, respectively. This lagoon will also be filled to about elevation 410 with an acidic solution having a pH of 1 or 2. However, the fluid level in this pond will fluctuate daily from an essentially empty to full condition. We understand the lagoon will always contain fluid to a depth of at least one foot. This lagoon will be cleaned about once every year by utilizing conventional construction equipment.

3 - <u>Storage Lagoon Drain Line</u> - The storage lagoon drain line will be a fiber reinforced polyester pipe 20 inches in diameter and approximately 140 feet in length. This drain line will extend from the northwest corner of the storm water storage lagoon to the eastern side of the existing pumping station. The drain line will range

in elevation from 399 at the storage lagoon to 395 at the pumping station.

4 - Storm Water and Process Surge Line - This line will consist of a fiber reinforced polyester pipe 48 inches in diameter and approximately 500 feet in length. The pipe will be established at a depth of approximately one foot below grade and will extend from the existing pumping station to a point between the two lagoons. The pipe will be installed along the north side of the existing and proposed facilities.

5 - Sludge Handling Facilities - The sludge handling facilities will be housed in a light weight superstructure. The type of equipment which will be utilized in handling the sludge will be comprised of two drum type filters. Each filter will consist of a semi-cylinder 12 feet in diameter and 18 feet in length. The cylinders will weigh on the order of 9 tons each and will be supported at each end by two legs which will rest on rectangular concrete pads. Each cylinder will contain approximately 10 tons of sludge.

6 - Grit Chamber - The grit chamber will be approximately a 23-foot square concrete basin established 10 to 12 feet below grade.

The walls of the structure will extend to about 3.5 feet above grade. The grit chamber will be filled with water to about 1.5 feet above grade at all times.

7 - Surge Chamber - The surge chamber will be a fiber reinforced polyester tank which will have a 10,000 gallon capacity.

8 - Lime Storage Silos - Each silo will be approximately 16 feet in diameter, 30 to 40 feet in height and will store on the order of 100 tons of lime. The silos will be constructed side-by-side and supported on a steel grating platform about 12 feet above the ground surface. A lime slaker will also be supported on the platform directly below each silo. Each slaker will weigh about two tons and will be filled with a solution having a specific gravity of 1.3. The slakers will be 4 feet by 6 feet by 9 feet. The steel platform will be supported by six columns. A milk of lime storage tank will be located directly below the steel platform. This tank will contain 3000 gallons of fluid having a specific gravity of 1.3.

9 - Neutralization Chambers - Three neutralization chambers, each approximately a 23-foot square in plan dimensions, will be constructed adjacent to each other in series. The chambers will extend about 20 feet below grade and about 5 feet above grade. An overhead mixer will be constructed above each chamber. The chambers, which will be filled at essentially all times, will contain water to a height of one foot above grade. It may be necessary to empty any one of the three chambers at any time.

10 - Scum Storage Tank - This tank will be located adjacent to the south side of the existing pumping station. The tank will be constructed of fiberglass and will be approximately 12 feet in diameter and 10 to 12 feet in height. It will contain about 10,000 gallons of a fluid having a specific gravity of 0.85 and will be supported at grade on a circular pad.

11 - Flocculation Chambers - Two flocculation chambers will be constructed adjacent to the west end of each existing chemical clarifier. The flocculation chambers will be approximately 20 feet by 30 feet in plan dimensions and will extend to a depth of approximately 10 feet below final grade. These chambers will be

constructed of concrete and will contain equipment weighing approximately 1000 pounds. The water level within the chambers will be at about elevation 410.

12 - Rapid Mix Chambers - A rapid mix chamber, approximately 8-foot square in plan dimensions, will be constructed west of and between each set of flocculation chambers. These chambers will also be constructed of concrete and will extend to a depth of approximately 6 feet below final grade. Water will flow from the splitter box to each of these chambers at about elevation 410. Each chamber will contain about 500 pounds of equipment.

13 - Appurtenant Facilities - Appurtenant facilities which will be constructed at the plant include: (1) a splitter box and (2) an open concrete trench. The splitter box and open concrete trench will be established at about 2 feet below grade. Water will flow through these structures at approximately elevation 410.

14 - Existing Chemical Clarifiers - There are two existing chemical clarifiers (retention ponds) with side slopes of 2.5 horizontal to 1.0 vertical which will be redesigned to

have vertical concrete walls. The concrete walls will be supported by continuous wall footings. The bottom concrete slab of the clarifiers will be established at about 10 feet below grade. Existing wood piles will support an overhead bridge and rake. The area between the concrete walls and existing side slopes will be backfilled with soil.

SITE CONDITIONS

SURFACE CONDITIONS

The areas proposed for construction of the various new facilities are located either within or adjacent to the existing Village of Saugett Waste Treatment Plant. The Village of Sauget, Illinois, is located southwest of East St. Louis, Illinois, on the Mississippi River flood plain. The locations of the proposed and existing facilities are shown on Plate 1, Plot Plan.

The site is relatively level and primarily slopes gently downward from about elevation 409 at the western boundary to about elevation 405 at the eastern edge of the proposed storm water bypass clarifier. The ground surface elevation rises to approximately elevation 410 in a localized area directly west of the existing chemical clarifiers. The existing chemical clarifiers have steeply diked slopes on the remaining three sides which range in elevation from approximately 407 to 411.

The portions of the site located within the existing plant and not presently occupied by existing structures or facilities are either gravel covered, covered with grass and/or weeds, or void of any vegetation. A fence presently encompasses the existing plant site. The area adjacent to and north of the existing plant site is presently being farmed and is covered with wheat.

SUBSURFACE CONDITIONS

The subsurface conditions in the areas of the proposed facilities were investigated by drilling nine exploration test borings at the locations shown on Plate 1. Detailed descriptions of the subsurface conditions encountered at each test boring location are presented on the Log of Borings in the APPENDIX of this report.

The borings revealed that portions of the site are covered with fill ranging in depth from 8.5 to 15 feet below the existing ground surface. The fill, consisting primarily of loose to medium dense gray and/or brown silty fine sand containing occasional cinders and pieces of concrete, was encountered in Borings 4, 5, 6, 8 and 9. The upper 15 feet of the remaining portions of the site consists primarily of medium dense, brown silty fine sand and/or fine sand.

Several borings encountered one to three-foot thick layers of fine sandy silt and silty clay at depths between 8.5 and 19 feet below the existing ground surface.

Below a depth of approximately 15 feet, the site is primarily underlain by deposits of fine or fine to medium sand. These sand deposits are generally medium dense to depths ranging from approximately 25 to 35 feet below the existing ground surface.

The medium dense sand deposits are in turn underlain by dense sand deposits which extend to depths of approximately 50 feet in Boring 5, 40 feet in Boring 9 and to the maximum depth penetrated by Boring 8 (61.5 feet). Very dense sand deposits were encountered at depths of about 40 feet and 50 feet in Borings 9 and 5, respectively.

GROUND WATER

An extensive study was made of the available literature concerning past and recent ground water conditions in the vicinity of the site. In addition, ground water levels were recorded at the completion of each test boring and are shown on the Log of Borings presented in the APPENDIX of this report. Observation wells were installed in two of the borings and were monitored for more than two weeks. Generally, the recorded ground water levels indicated that the ground water table varied from approximately elevation 388 to 390 at the time of our field investigation.

The literature review revealed that the plant site is located within an area known locally as the "American Bottom." This area includes portions of Madison, St. Clair and Monroe Counties and extends along the valley lowlands of the Mississippi River from the City of Alton south to the Village of Dupo. It is one of the most heavily populated and industrialized areas in Illinois. The ground water resources of a sand and gravel acquifer underlying the area have been extensively developed.

Prior to the settlement of the East St. Louis area, the ground water table was very near the ground surface and shallow lakes, ponds, swamps and poorly drained areas were widespread. The general direction of movement of ground water was west and south toward the Mississippi River and other streams and lakes. The estimated piezometric surface prior to heavy industrial development (prior to the year 1900) sloped from about elevation 420 near the bluffs at the edge of the "American Bottom" to about elevation 400 near the Mississippi River and plant site.

The establishment and development of industrial centers and the subsequent use of large quantities of ground water by industries and municipalities have lowered water levels appreciably in the "American Bottom." Pumpage in the Sauget area increased considerably from less than 100,000 gallons per day in 1903 to 33.2 million gallons per day (mgd) in 1960. Pumpage growth was fairly uniform from 1903 to 1939, accelerated sharply during World War II, and continued to climb with only minor interruptions after World War II. The ground water withdrawals are for the most part from wells owned by less than 20 industries; the greatest use of water is by chemical plants.

Since about 1962 to present, the Sauget area has perienced a decline of pumpage quantities from 36.5 mgd in 1962 to 12.8 mgd in 1971, resulting in an apparent 33-foot rise of the ground water table.

Recorded water level data for wells located in the Monsanto area about three-quarters of a mile from the Mississippi River have shown that large changes in the stage of the Mississippi River result in comparatively small changes in the water levels in the wells. A rise of about 20 feet in the river stage results in a rise on the order of 5 feet in the water levels in the wells.

Based on the literature review, it is apparent that the ground water levels in the vicinity of the plant site are highly dependent on industrial pumpage rates and mildly dependent on the stage of the Mississippi River. In the event that essentially all industrial pumpage in the Sauget area would cease, it is estimated that the ground water table will rise to approximately the same elevation at which it existed prior to industrialization in 1900 (elevation 400). The Mississippi River is subject to yearly floods which result in raising the ground water level about 5 feet in the vicinity of the plant site. It is therefore conceivable that a condition may occur in which the ground water level would rise to about elevation 405.

FROST

The maximum depth of frost penetration in the vicinity of the site is on the order of three feet.

DISCUSSION AND RECOMMENDATIONS

GENERAL

It is recommended that the proposed facilities, with the exception of the sludge handling facilities building and the drum type filters contained therein, be supported on mat-type foundations. The sludge handling facilities building and the drum type filters may be satisfactorily supported utilizing spread foundations. The subgrade soils beneath all proposed facilities should be prepared in the manner specified in the SITE PREPARATION AND EARTHWORK section of this report.

Based on a review of the available literature pertaining to the past and recent ground water conditions which existed in the vicinity of the site, it is recommended, for design purposes, that the potential future ground water level be considered capable of rising to elevation 405. During the course of our field investigation the present ground water level at the site was recorded at elevations generally ranging from approximately 388 to 390. Since the bottom of the neutralization chambers' base slab will be established at approximately elevation 389, some dewatering operations during construction will be required. It is anticipated that the required dewatering can be accomplished by pumping from sumps and/or collector ditches located throughout the bottom of the excavation.

It is our opinion that cohesive (fine-grained) borrow materials, suitable for purposes of constructing an impermeable liner in the two lagoons, exist in the general vicinity of the site. The actual type of material used and the required haul distance are functions of the type and location of suitable material available at the time of construction. During our field investigation several bulk samples of potential borrow materials were obtained. Two of these bulk samples were tested in our laboratory and the results of these tests are presented in the APPENDIX of this report. Recommendations regarding the type of material to be used and the placement of that material for purposes of constructing an impermeable lagoon liner are presented in the subsequent LAGOONS section of this report.

Our recommendations and results of engineering analyses pertaining to allowable bearing pressures, estimated settlements and the design of structures which extend below grade are presented in subsequent sections of this report. Recommendations pertaining to earthwork operations required to prepare the site, attain planned grades and install foundations are presented in the following section.

SITE PREPARATION AND EARTHWORK

Site preparation and earthwork operations will consist of stripping, excavating, dewatering, proof-rolling, and the placement and compaction of fill materials. We recommend that all earthwork operations be supervised by a qualified engineer.

Stripping - It is recommended that all topsoil and vegetation in the immediate vicinity of the proposed construction be stripped from the site and wasted. It is estimated that the average depth of stripping will be on the order of 12 inches.

Excavating - Excavations will be required to construct the two retention ponds, the grit chamber, the neutralization chambers, the flocculation chambers and the rapid mix chambers; to install foundations, two pipelines, the concrete trench and the splitter box; and to properly prepare the subgrade soils beneath the silos and the scum storage tank. The depths of the excavations will range from several feet to approximately 20 feet below the existing ground surface. The excavations required to construct the two retention ponds should be cut on slopes no steeper than 3.0 horizontal to 1.0 vertical. It is recommended that all temporary excavations less than 10 feet in depth be cut on slopes no steeper than 1.0 horizontal to 1.0 vertical. Temporary excavations greater than 10 feet in depth should be cut on slopes no steeper than 2.0 horizontal to 1.0 vertical.

It is recommended that the in-place fill soils underlying the mat-type foundations which will support the proposed silos and other relative equipment and the proposed scum storage tank be overexcavated to a depth of one foot below the bottoms of the proposed foundations and replaced with compacted granular fill. The excavated fill soils may be reused for general backfilling purposes provided that all cinders, pieces of concrete and other miscellaneous debris are first removed.

Dewatering - It is anticipated that dewatering operations will be required during construction of the neutralization chambers. Since the bottom of the proposed base slab will be established at approximately elevation 389 and the ground water table is at approximately elevation 390, it is our opinion that dewatering can be accomplished by pumping from sumps and/or collector ditches established at various locations throughout the bottom of the excavation. It is recommended that the ground water level be maintained at a minimum depth of two feet below the bottom of the base slab prior to and during its construction. It is not anticipated that any other dewatering operations will be required.

Proof-rolling - The bases of all excavations and stripped surfaces should be proof-rolled prior to the placement of fill or pouring of concrete to detect any localized disturbed areas and to densify the underlying subgrade soils. Proof-rolling should be performed by making a minimum of three passes with vibratory compaction equipment capable of delivering a high amount of energy. Any localized disturbed soils detected during proof-rolling operations which cannot be readily compacted should be removed and replaced with approved, compacted granular fill.

Filling - The placement and compaction of both granular and cohesive fill will be required in the construction of the lagoon dikes and liners. It is estimated that the peripheral dikes will range in height from approximately 5 to 8 feet above the existing ground surface. It is recommended that the on-site soils excavated from within the proposed lagoon areas be used as fill in construction of the dikes.

The granular fill should be placed in lifts not exceeding eight inches in loose thickness and should be compacted to a minimum dry density of 90 percent of the maximum dry density as determined in accordance with AASHO* Test Designation T-130. It is recommended that the compaction be achieved by utilizing vibratory compaction equipment.

Subsequent to completion of the proof-rolling operations and construction of the peripheral dikes, a cohesive liner will be placed over the bottoms and entire interior side slopes of both lagoons. The cohesive liner should consist of an approved impermeable material resistant to acidic solutions having a pH on the order of 1 to 2. It is recommended that the cohesive liner be a minimum of 15 inches thick.

The cohesive fill should be placed at a moisture content within two to six percent on the wet side of the optimum moisture

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*American Association of State Highway Officials content and in lifts not exceeding six inches in loose thickness. Each lift should be compacted to a minimum dry density of 90 percent of the maximum dry density as determined in accordance with AASHO Test Designation T-180. Some drying of the imported cohesive material may be required prior to compaction. The placement, drying and compaction of cohesive fill cannot be achieved during periods of wet or freezing weather. Compaction should be achieved by utilizing either sheepsfoot rollers or heavy pneumatic-tired compaction equipment. Subsequent to attaining the required degree of compaction, each lift should be scarified. The surface of the top layer should be sealed.

It is recommended that an additional one foot thick layer of granular soils be placed and compacted over the impermeable cohesive liner for protection against damage which may occur during cleaning operations. The granular pad would serve as a working surface for the construction equipment utilized during cleaning. This additional one foot thick layer would also be beneficial since it would minimize the degree to which the cohesive liner would be exposed to the elements. Therefore, the amount of cracking, which is a function of the shrink-swell characteristics of the cohesive material used,should be minimal.

<u>Backfilling</u> - Backfilling will be required adjacent to substructure walls, over foundations and pipelines, and in the over-excavated areas beneath the proposed silos and scum storage tank. Bachfill placed outside of the exterior

substructure walls of the neutralization chambers, the flocculation chambers, the rapid mix chambers, the existing chemical clarifiers and the grit chamber, and over the two pipelines, may consist of on-site, excavated natural or fill soils. If excavated fill soils are used, they should be free of cinders, pieces of concrete and any other miscellaneous debris. Backfill used to raise the subgrade level in the over-excavated areas up to the bottoms of proposed foundations and over spread foundations should consist of clean granular material such as on site, excavated sand or sand and gravel. It is anticipated that the material which will be excavated from below a depth of approximately 10 feet during construction of the neutralization chambers will be suitable for this purpose.

Backfill material which is not intended to provide any structural support, and that which is placed outside of exterior substructure walls, over spread foundations and over the two pipelines may be placed in lifts up to eight inches in loose thickness. Each lift should be compacted to a minimum dry density of 90 percent of the maximum dry density as determined in accordance with AASHO Test Designation T-180. Backfill material placed for the purpose of raising the subgrade level in the over-excavated areas and in any other areas intended to support structural loads should be placed in lifts not exceeding six inches in loose thickness. Each lift should be compacted to a minimum dry density of 100 percent of the maximum dry density as determined in accordance with AASHO Test Designation T-180. It is recommended that all backfill material be compacted by utilizing vibratory compaction equipment.

FOUNDATIONS

Design Data - It is our opinion that the proposed lime storage silos, scum storage tank, grit chamber, surge chamber, neutralization chambers, flocculation chambers and rapid mix chambers may be satisfactorily supported on mat-type foundations founded on subgrade soils consisting of either natural, in-place soils or well compacted fill. The columns of the sludge handling facilities building and the drum type filters contained within the building may be supported on spread foundations established in the natural soils. All foundations should have a minimum plant dimension of 18 inches and should be established at a minimum depth of three feet below the lowest adjacent final grade.

Provided the foundations are designed acknowledging the above limitations and are installed in accordance with the recommendations presented in the following section, the foundations may be proportioned utilizing an allowable bearing pressure of up to 2,000 pounds per square foot. This bearing pressure refers to the total design loads, dead and live, and is a net pressure. Therefore, the weight of the concrete in the foundations and the weight of the backfill over the foundations may be ignored in proportioning the foundations.

Installation - The proposed structures are located in areas underlain by either loose, in-place fill or medium dense natural soils. Accordingly, recommendations regarding the preparation of subgrade soils for foundations established in both of these types of material have been provided in the previous SITE PREPARATION AND EARTHWORK section of this report.

Settlement - Provided that the foundations are designed and installed in accordance with the above recommendations, it is estimated that the proposed structures will undergo settlements on the order of one-half inch or less. It is anticipated that essentially all of the estimated settlement will occur during the initial application of the loads.

HYDROSTATIC UPLIFT FORCES

Based on information obtained from our review of available literature pertaining to past and recent ground water conditions which existed in the vicinity of the site, it is recommended that hydrostatic uplift forces be considered in the design of all structures which will extend below elevation 405. Elevation 405 is the estimated maximum ground water level which may occur at the site in the future.

The hydrostatic uplift forces acting on the base slabs of the grit chamber, the neutralization chambers, the flocculation chambers, the rapid mix chambers, and the existing chemical clarifiers may be resisted by the dead weight of the structure, the weight of the fluid contained in the structure and by frictional forces acting on the sides of the structure. The frictional resistance developed from adjacent backfill may be computed by considering the granular backfill to act as an equivalent fluid with a density of 40 pounds per cubic foot above the ground water level and 20 pounds per cubic foot below the ground water level, and by utilizing a coefficient of friction equal to 0.30 between the concrete walls and granular backfill. The use of the above recommended values will provide a factor of safety on the order of 1.0. It is recommended that a factor of safety be chosen which is compatible with the structural and functional considerations of the proposed facilities.

The hydrostatic uplift forces acting on the base of the impermeable cohesive liner in the two lagoons will be resisted by the shearing strength of the material used as the liner and by the weight of the fluid contained in the lagoons. It is strongly recommended that the water level in the lagoons be maintained at or above the ground water level outside of the lagoons at all times. Safety valves installed in the base of the lagoons would serve as a precautionary measure against potential "blow out" type failures and are recommended.

LATERAL PRESSURES

All substructure walls should be designed to resist lateral pressures induced by either soil or soil and ground water depending on whether or not they extend below elevation 405. It is recommended that the lateral pressures acting on the walls be computed by considering the adjacent compacted granular backfill above the design ground water level to act as an equivalent fluid with a density of 65 pounds per cubic foot. Below the design ground water level, the backfill and water should be considered to act as an equivalent fluid with a density of 95 pounds per cubic foot. The above recommendations pertain to a rigid wall restraint condition and assume that the backfill material will be placed and compacted in accordance with the procedures specified in the SITE PREPARATION AND EARTHWORK - Backfilling section of this report.

Due to the effect of lateral pressures resulting from surcharge pressures, it is recommended that the proposed scum storage tank be located at a minimum lateral distance of one foundation diameter from the existing pumping station walls. The above recommendation may be ignored if it is known that the substructure walls of the existing pumping station have been adequately designed and constructed to resist such lateral pressures.

OBSERVATION WELLS

It is recommended that two permanent observation wells be installed for the purpose of monitoring the ground water level within the site. The wells should extend to approximately elevation 375. It is suggested that one of the wells be located in the general vicinity of the proposed neutralization chambers and that the other well be located near the east side of the proposed storm water bypass clarifier, thereby providing good coverage across the site.

The ground water level should be monitored prior to and during the removal of fluid from any structure or facility which extends below elevation 405. By monitoring the ground water level an additional margin of safety is provided against possible "blow out" type failures occurring due to the development of excessive hydrostatic pressures.

LAGOONS

Earthwork operations consisting of stripping, excavating, proof-rolling and the placement and compaction of both granular and cohesive fill will be required in the construction of the lagoon dikes and liners. It is estimated that the peripheral dikes will range in height from approximately 5 to 8 feet above the existing ground surface. All earthwork operations should be performed in accordance with the procedures specified in the previous SITE PREPARATION AND EARTHWORK section of this report.

During our field investigation, several bulk samples of potential cohesive borrow materials were obtained from within the general vicinity of the site. Extensive laboratory tests were performed on two of the bulk samples. Descriptions of the two types of materials tested are: (1) reddish brown silty clay with a trace of sand and fine gravel and (2) gray silty clay. The results of the laboratory tests performed indicate that:

1 - the two types of materials have similar permeability characteristics,

2 - the gray soil has a much higher in-place field moisture content,

3 - the gray soil has a lower remolded maximum dry density,

4 - the gray soil is much more plastic, and

5 - the gray soil exhibited much higher potential shrink-swell characteristics.

Based on the results of the laboratory tests performed on the two soils considered to be representative of the types of potential borrow materials available in the general vicinity of the site, it is recommended that a material having physical properties similar to those exhibited by the reddish brown silty clay be used to construct the impermeable liners for the lagoons.

Seepage studies were performed for both proposed lagoons based on the results of the laboratory permeability tests and on the recommendations presented in the SITE PREPARATION AND EARTHWORK - Filling section of this report. It is estimated that the seepage losses in the proposed storm water storage lagoon and storm water bypass clarifier will be less than 15 cubic feet per day and 40 cubic feet per day, respectively. The above estimates represent seepage losses occurring each day which are less than 0.02 percent of the total volume of each respective lagoon. If the above estimated seepage losses are not satisfactory, it is suggested that the thickness of the impermeable liner be increased in proportion to the desired reduction of seepage losses.

PIPELINES AND APPURTENANT FACILITIES

The earthwork operations required to install the proposed pipelines and to construct the open concrete trench and splitter box should be performed in the manner specified in the SITE PREPARATION AND EARTHWORK section of this report. Provided the recommendations presented in this report are followed, it is estimated that the above facilities will undergo negligible settlements.

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The following PLATE and APPENDIX are attached and complete this report.

PLATE 1 - PLOT PLAN

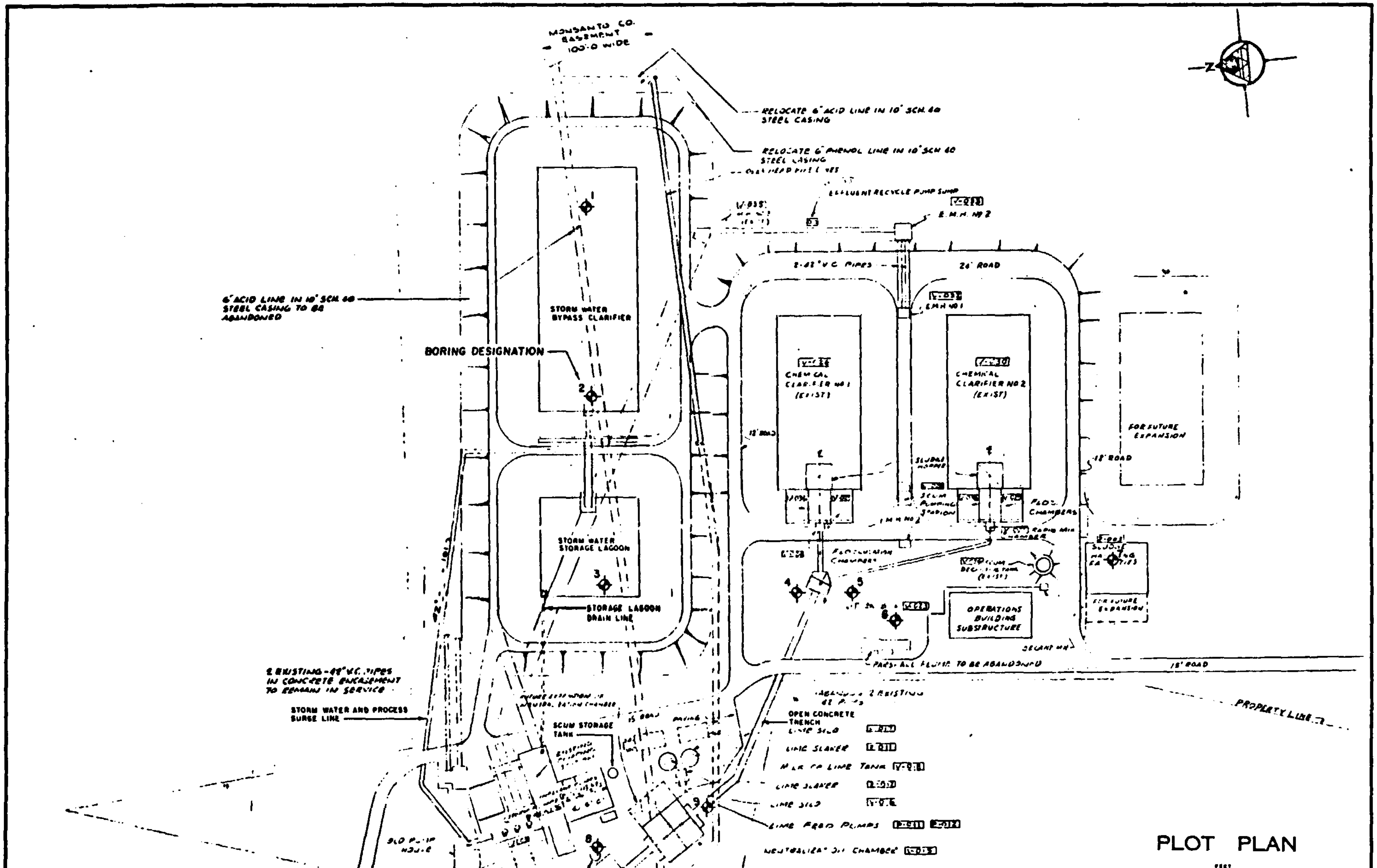
APPENDIX - FIELD EXPLORATIONS AND LABORATORY TESTS

Respectfully submitted,

DAMES & MOORE

James B. Thompson

James B. Thompson
Partner



DRAWING REFERENCE:
TITLED: PLOT PLAN WASTEWATER TREATMENT SYSTEMS
FOR: VILLAGE OF SAUGET, ILLINOIS
BY: MONSANTO ENVIRO-CHEM SYSTEMS INC.
DRAWING NO.: 3-1
DATED: 5-10-73

PLATE I

APPENDIX

FIELD EXPLORATIONS AND LABORATORY TESTS

FIELD EXPLORATIONS

Test Borings - The subsurface conditions at the site of the proposed construction were investigated by drilling nine exploration test borings to depths ranging from 21.5 feet to 61.5 feet below the existing ground surface. The test borings were drilled utilizing truck-mounted auger and rotary-wash type drilling equipment.

The field operations were supervised by one of our engineers, who classified the soil and fill encountered in the borings, maintained a log of the borings, and obtained undisturbed and disturbed soil samples of the strata encountered in the borings for visual examination and laboratory testing. Graphical representations of the soils penetrated by the borings are presented on Plates A-1A through A-1F, Log of Borings. The method utilized in classifying the soils is defined on Plate A-2, Unified Soil Classification System. Undisturbed samples of the various soil strata penetrated by the borings were obtained in a soil sampler of the type illustrated on Plate A-3, Soil Sampler Type U. Disturbed soil samples were obtained in a two-inch O.D. split spoon sampler.

The boring locations were staked in the field by our engineer. The ground surface elevation and surveyed location of each boring were later determined and provided to us by the

Myers, Keller and Byers Company of St. Louis, Missouri. The ground surface elevations are presented above the log of each boring and refer to U.S.G.S. Datum.

Observation wells consisting of one-inch I.D. PVC pipe were installed in two of the borings. Holes were drilled in the bottom five feet of pipe prior to installation. The borings were flushed with clear water and backfilled to the ground surface with granular material after the pipe was installed. The ground water levels in the two observation wells were monitored for a period of more than two weeks after installation and the stabilized water levels are presented on the Log of Borings. Ground water levels were also recorded after the completion of each of the remaining borings and are presented on the Log of Borings.

Borrow Material Investigation - A field investigation for clay borrow material was performed in the general vicinity of the site by our engineer. Several earthwork contractors and private individuals were contacted in our search for clay borrow material suitable for use as a lining in the lagoons. Bulk samples of the various types of material found were obtained and returned to our office for visual inspection and laboratory testing.

The two bulk samples subjected to laboratory testing are considered representative of the types of cohesive borrow material available in the general vicinity of the site. The reddish brown silty clay sample was provided by Mr. Tom Baughman of Earthmoving, Inc., St. Louis, Missouri. This bulk sample was obtained from an area located about three miles south of Interstate Route 244 and just west of Interstate Route 55 near St. Louis. Mr. Baughman indicated that this type of material was available in this general area near St. Louis and that the cost of the material delivered to the site would be on the order of \$2.50 to \$3.00 per cubic yard. The above estimate was based on a haul distance of approximately 20 to 25 miles and assumes that no local labor problems will exist at the time when the material is required. The gray silty clay sample was obtained from the private residence of Bill Courtney Farms, 8251 Bunkum Road, Caseyville, Illinois.

LABORATORY TESTS

Strength Tests - Direct shear tests were performed on selected granular soil samples to determine the strength characteristics of the various soil strata penetrated by the borings. The tests were performed in the manner described on Plate A-4, Method of Performing Direct Shear and Friction Tests. Load-versus-deflection curves were plotted for each strength test performed and the shearing strengths of the soils were determined from these curves. The shearing strengths presented are the peak shearing strengths obtained. Strength test results are shown to the left of the Log of Borings in the manner described by the Key to Test Data shown on Plate A-2.

Moisture-Density Tests - Determinations of the moisture content and dry density were made in conjunction with each strength test. Additional moisture-density tests were made for correlation purposes. The results of all moisture-density determinations are presented to the left of the Log of Borings in the manner described by the Key to Test Data shown on Plate A-2.

Atterberg Limits Tests - Atterberg limits tests were performed on two of the bulk soil samples obtained in the clay borrow material investigation. The Atterberg limits, consisting of the liquid limit and plastic limit, and the resulting plasticity index were determined to facilitate classification of the soils according to the Unified Soil Classification System. The results of the Atterberg limits tests are presented below:

SOIL DESCRIPTION	SOIL TYPE	FIELD MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)
Reddish brown silty clay with a trace of sand and fine gravel	CL	22.5	49.0	19.9	29.1
Gray silty clay	CH	43.4	94.5	31.4	63.1

Particle Size Distribution - The particle size distribution was determined for two of the bulk soil samples obtained in the clay borrow material investigation for classification purposes. Results of the analyses are presented on Plates A-5A and A-5B, Particle Size Distribution.

Permeability Tests - Falling head and constant head type permeability tests were performed on representative undisturbed soil samples extracted from the test borings and on remolded samples of soil obtained in the clay borrow material investigation for purposes of estimating seepage losses in the lagoons.

The results of the constant head type permeability tests performed on the undisturbed samples extracted from the borings are presented below:

BORING NUMBER	DEPTH (FEET)	SOIL TYPE	FIELD MOISTURE CONTENT (%)	FIELD DRY DENSITY (PCF)	AVERAGE COEFFICIENT OF PERMEABILITY AT 20°C K (cm/sec)
1	8	SP	5.4	98.2	6.8×10^{-4}
3	5	SM	14.7	89.5	8.5×10^{-4}

The results of the falling head type permeability tests performed on the remolded samples of soils obtained in the clay borrow material investigation are presented below:

SOIL DESCRIPTION	SOIL TYPE	REMOLDED DATA: DRY DENSITY (PCF)	PERCENT OF COMPACTION	MOISTURE* CONTENT (%)	AVERAGE COEFFICIENT OF PERMEABILITY AT 20°C K (cm/sec)
Reddish brown silty clay with a trace of sand and fine gravel	CL	99.9	89.2	20	1.7×10^{-7}
Reddish brown silty clay with a trace of sand and fine gravel	CL	99.7	89.0	20	6.5×10^{-8}
Gray silty clay	CH	95.2	91.6	23	2.4×10^{-8}
Gray silty clay	CH	93.0	89.5	23	4.4×10^{-8}

Compaction Tests - Compaction tests were performed on two representative samples of potential clay borrow materials. The compaction tests were performed in accordance with AASHO Test Designation T-180. This method of compaction is described on Plate A-6, Method of Performing Compaction Tests (Standard and Modified AASHO Methods). The results of the compaction tests are presented on Plate A-7, Compaction Test Data.

Shrink-Swell Tests - The shrink-swell characteristics of two representative samples of potential clay borrow materials were evaluated by testing samples compacted to given dry densities and moisture contents. The samples were placed in a loading frame under a surcharge pressure of 50 pounds per square foot and allowed to air dry for four days. The samples were then

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*Moisture content at compaction prior to being tested.

saturated and allowed to swell until all noticeable swelling ceased. The samples were then again air dried. The volumetric shrinkage was computed by dividing the total volume change by the volume obtained after final air drying of the sample. The results of the shrink-swell tests are presented below:

SOIL DESCRIPTION	DRY DENSITY (PCF)	REMOLDED DATA PERCENT OF COMPACTION	 MOISTURE CONTENT* (%)	 AXIAL SWELL (%)	 VOLUMETRIC SHRINKAGE (%)	MOISTURE CONTENT AFTER FINAL AIR DRYING (%)
Reddish brown silty clay with trace of sand and fine gravel	99.1	88.5	21.4	3.1	14.0	12.9
Reddish brown silty clay with trace of sand and fine gravel	101.1	90.2	19.8	3.1	14.2	12.9
Gray silty clay	93.2	89.6	22.7	16.0	34.9	6.9
Gray silty clay	92.5	89.0	23.6	16.8	36.3	7.3

<u>Swell Pressure Tests</u> - Swell pressure tests were performed on two representative samples of potential clay borrow materials to evaluate their swelling characteristics. The tests were performed on samples remolded to designated dry densities and moisture contents. The samples were placed in consolidometers and saturated. Sufficient loads were applied at required intervals to prevent the samples from undergoing axial swelling. The results of the swell pressure tests are presented below:

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*Moisture content at compaction prior to being tested.

REMOLDED DATA

SOIL DESCRIPTION	DRY DENSITY (PCF)	PERCENT OF COMPACTION	MOISTURE CONTENT (%)	MAXIMUM SWELL PRESSURE (PSF)
Reddish brown silty clay with a trace of sand and fine gravel	99.8	89.0	20	1200
Gray silty clay	94.0	90.5	23	6000

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The following Plates are attached and complete this Appendix:

Plate A-1A - Log of Borings (Borings 1 and 2)

Plate A-1B - Log of Borings (Borings 3 and 4)

Plate A-1C - Log of Borings (Boring 5)

Plate A-1D - Log of Borings (Borings 6 and 7)

Plate A-1E - Log of Borings (Boring 8)

Plate A-1F - Log of Borings (Boring 9)

Plate A-2 - Unified Soil Classification System

Plate A-3 - Soil Sampler Type U

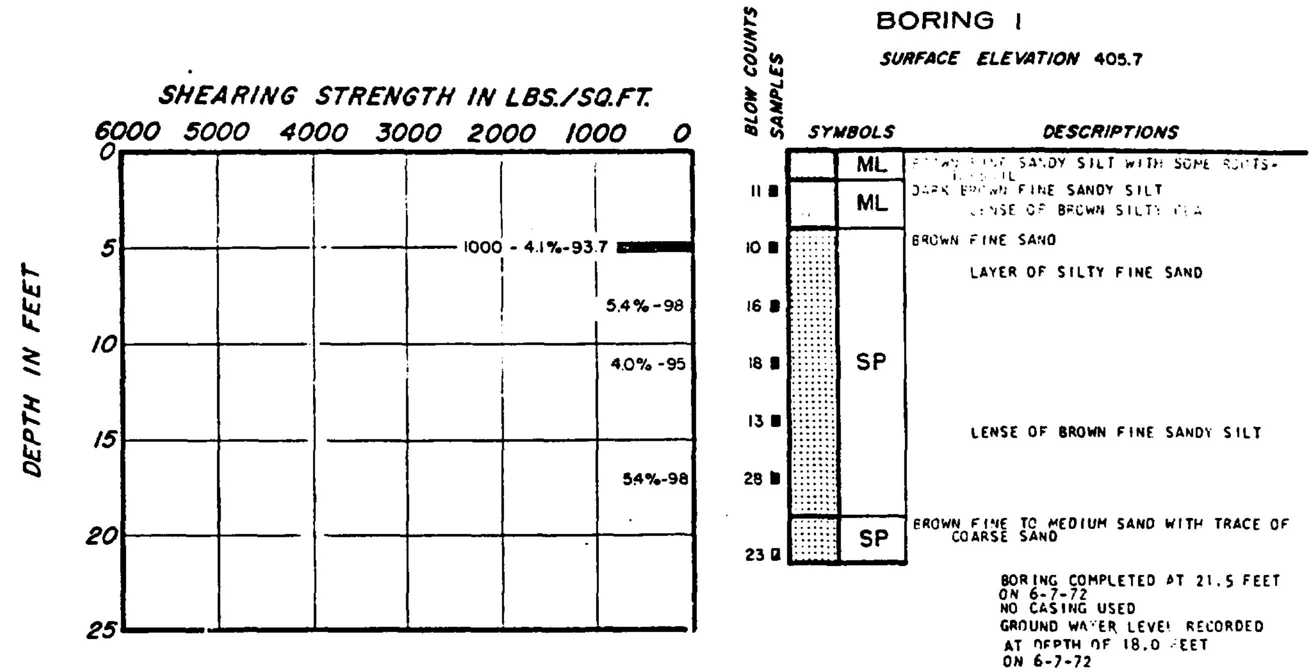
Plate A-4 - Method of Performing Direct Shear and Friction Tests

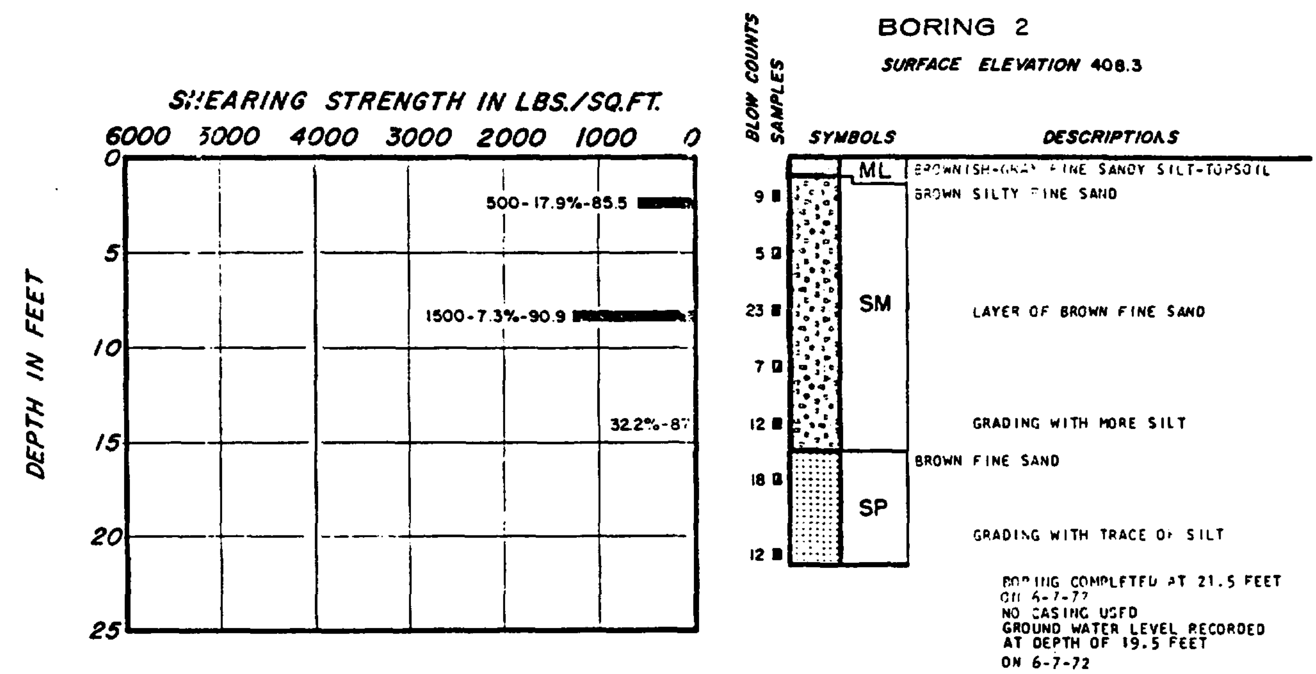
Plate A-5A - Particle Size Distribution

Plate A-5B - Particle Size Distribution

Plate A-6 - Method of Performing Compaction Tests (Standard and Modified AASHO Methods)

Plate A-7 - Compaction Test Data





NOTES:
GROUND SURFACE ELEVATIONS REFER TO U.S.G.S. DATUM

■ INDICATES A DAMES & MOORE UNDISTURBED SAMPLE.
8 FIGURES UNDER THE BLOW COUNT COLUMN INDICATE THE NUMBER OF BLOWS REQUIRED TO DRIVE THE DAMES & MOORE SAMPLER SHOWN ON PLATE A-3 THROUGH A DISTANCE OF ONE FOOT WITH A 355 POUND WEIGHT FALLING 24 INCHES.

LOG OF BORINGS

▣ INDICATES A STANDARD PENETRATION TEST.
8 FIGURES UNDER THE BLOW COUNT COLUMN INDICATE THE NUMBER OF BLOWS REQUIRED TO DRIVE A SPLIT SPOON SAMPLER HAVING AN OUTSIDE DIAMETER OF 2.0 INCHES THROUGH A DISTANCE OF ONE FOOT WITH A 140 POUND WEIGHT FALLING 30 INCHES.

DAMES & MOORE

PLATE A-1A

FILE 7644-002
BY NEL DATE 6-14-72
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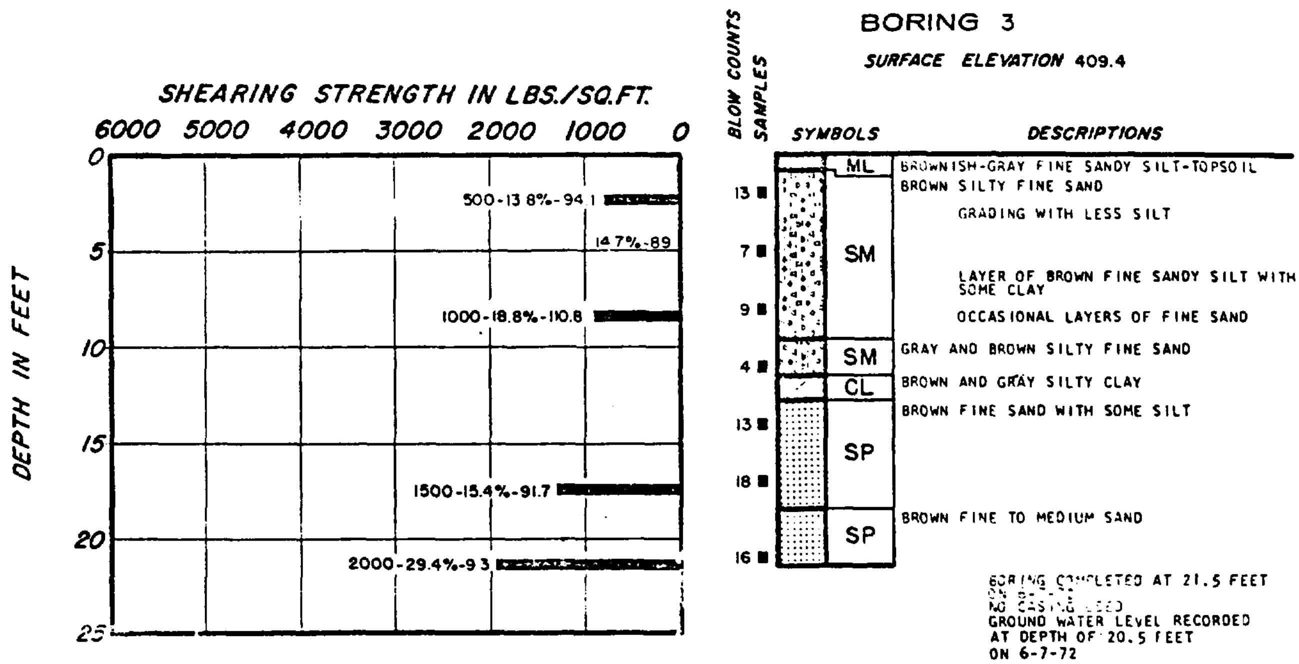
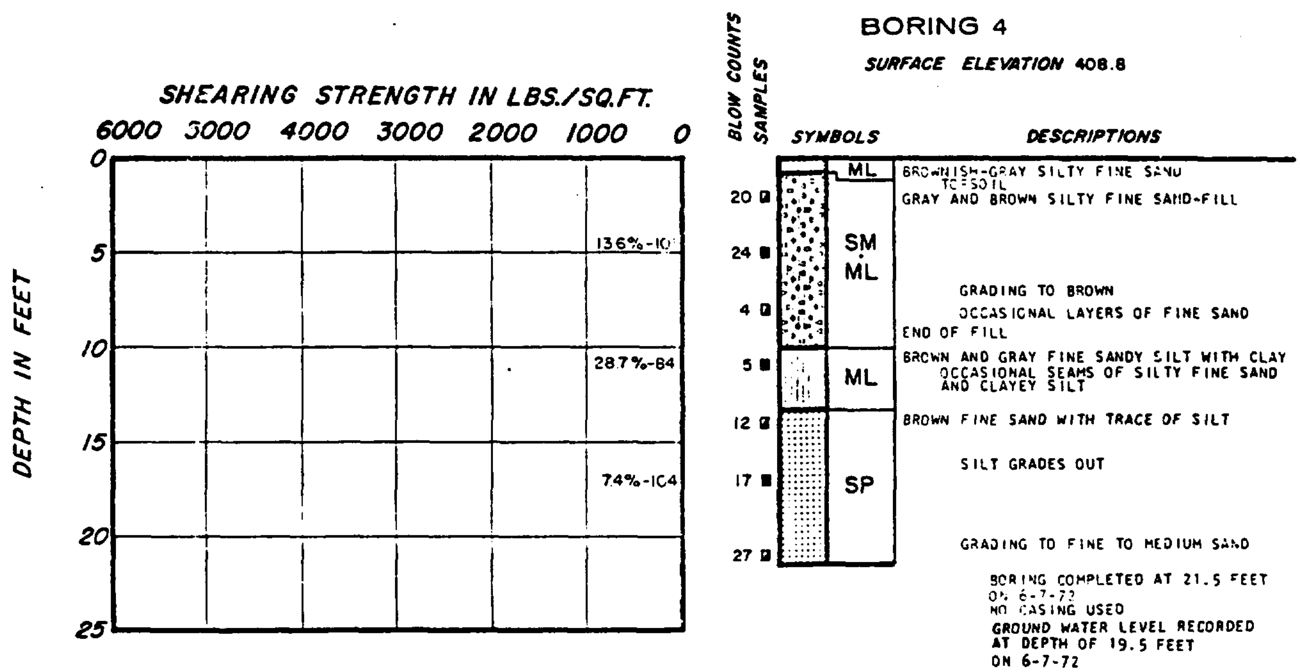




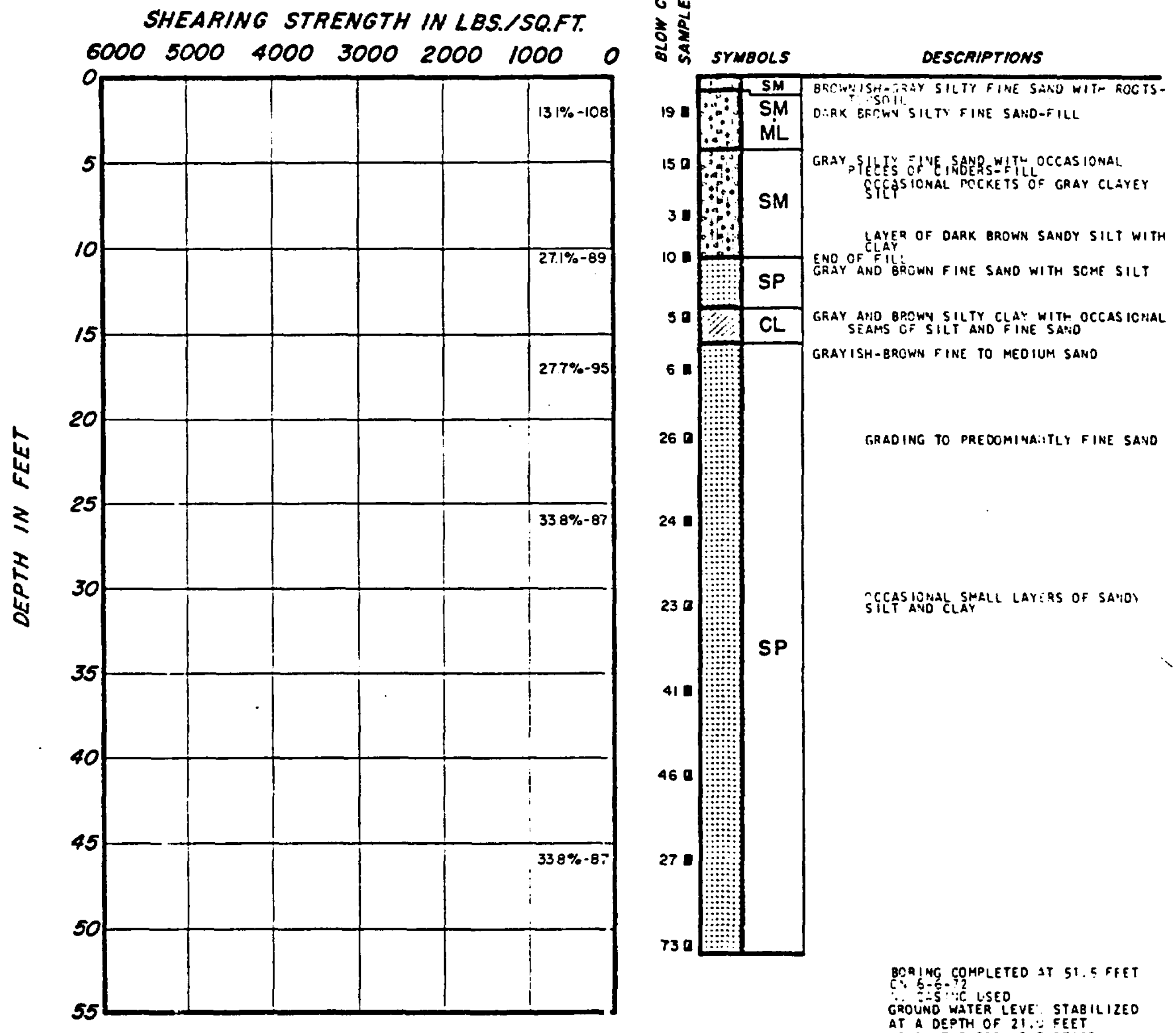
LOG OF BORINGS

DAMES & MOORE

PLATE A-1B

BORING 5

SURFACE ELEVATION 409.3



BORING COMPLETED AT 51.5 FEET
ON 6-6-72
NO CASING USED
GROUND WATER LEVEL STABILIZED
AT A DEPTH OF 21.0 FEET
BELOW THE GROUND SURFACE
ON 6-22-72

OBSERVATION WELL INSTALLATION:
ONE INCH I.D. PVC PIPE WAS INSTALLED TO A DEPTH OF 47 FEET. HOLES, APPROXIMATELY ONE-EIGHTH INCH IN DIAMETER, WERE DRILLED IN THE BOTTOM FIVE FEET OF PIPE. THE BORING WAS FLUSHED WITH CLEAR WATER AND BACKFILLED WITH GRANULAR MATERIAL TO THE GROUND SURFACE.

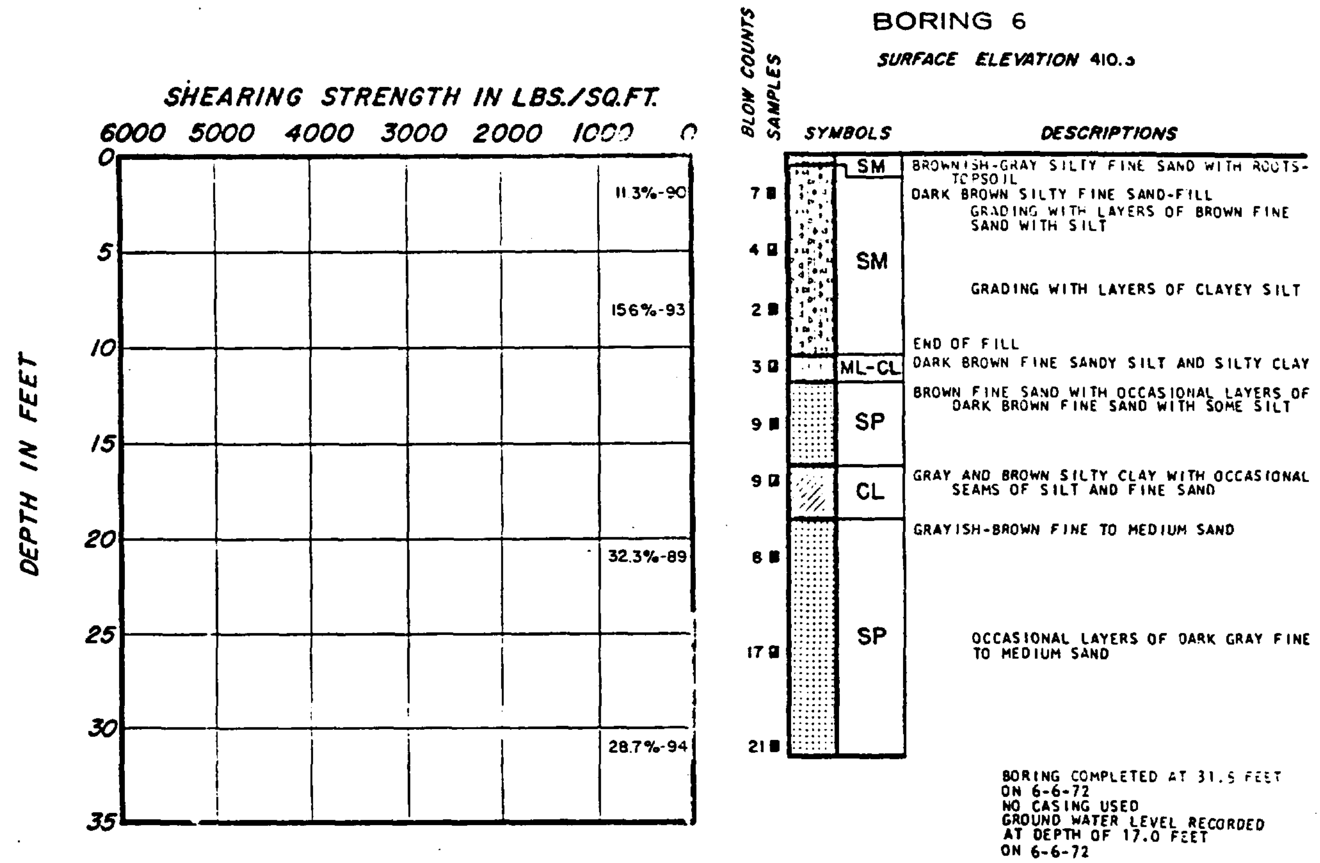
LOG OF BORINGS

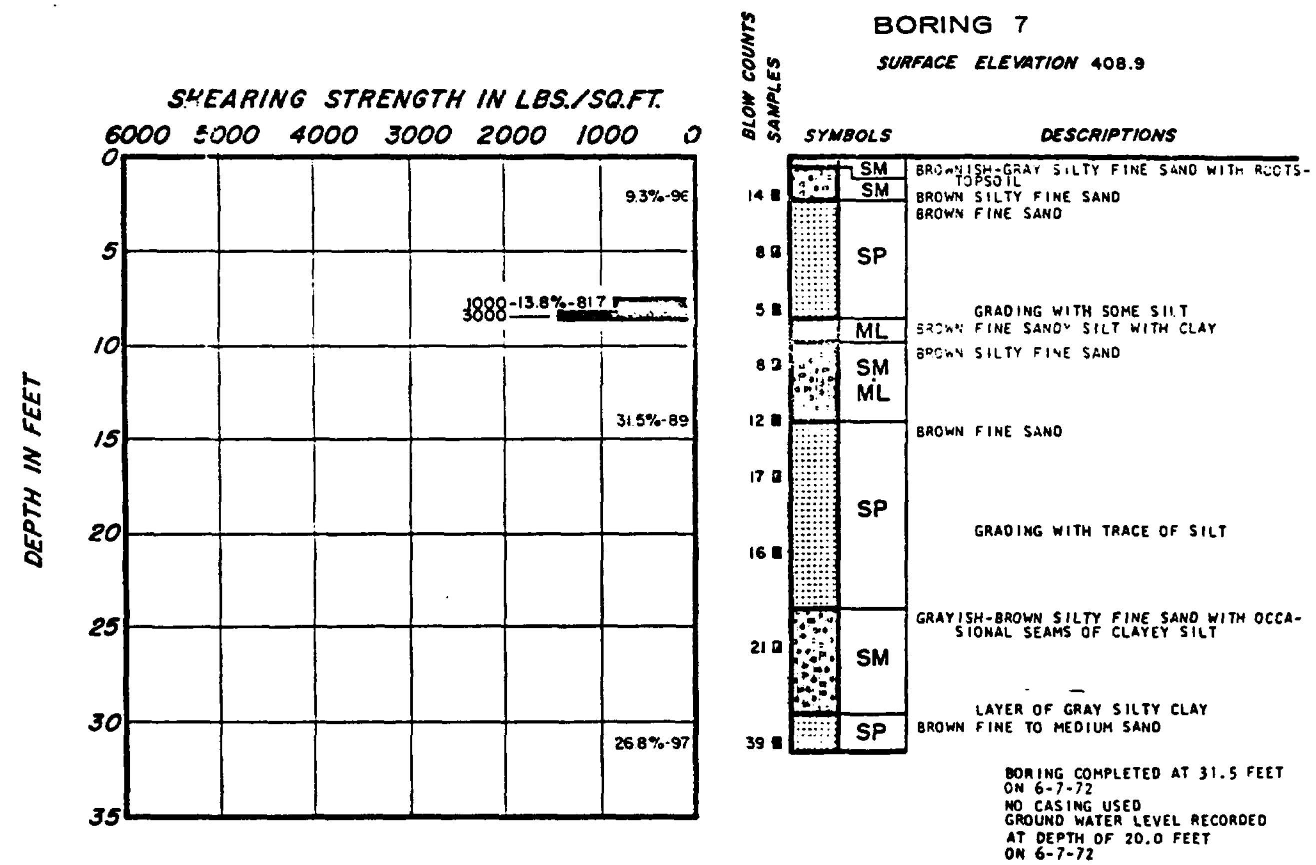
DAMES & MOORE

PLATE A-1C

REVISIONS BY___ DATE___ BY___ DATE___ PLATE___ OF___

FILE 7644-002 BY NEL DATE 6-14-72 CHECKED BY___ DATE___

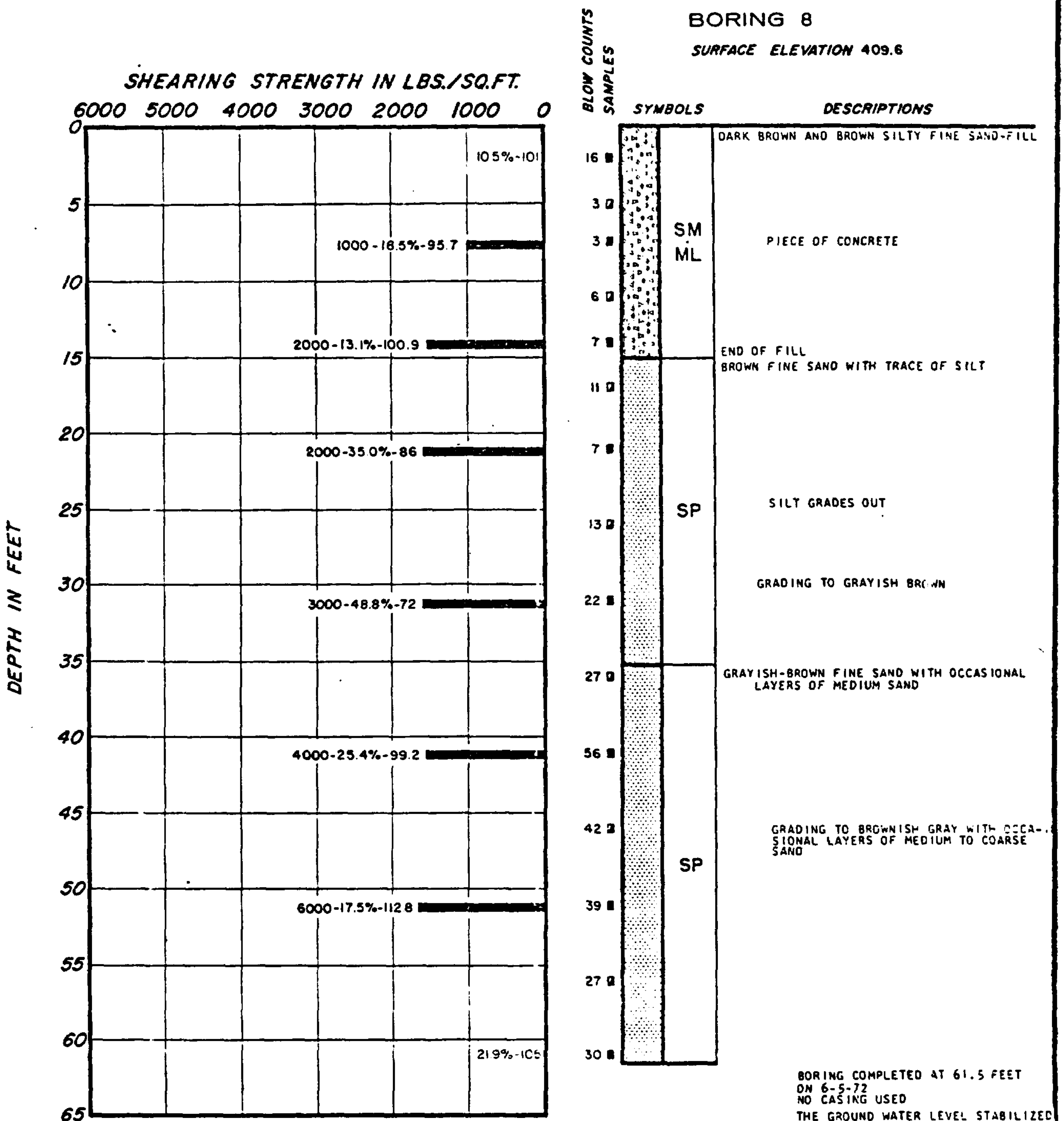




LOG OF BORINGS

DAMES & MOORE

PLATE A-1D



BORING COMPLETED AT 61.5 FEET
ON 6-5-72
NO CASING USED

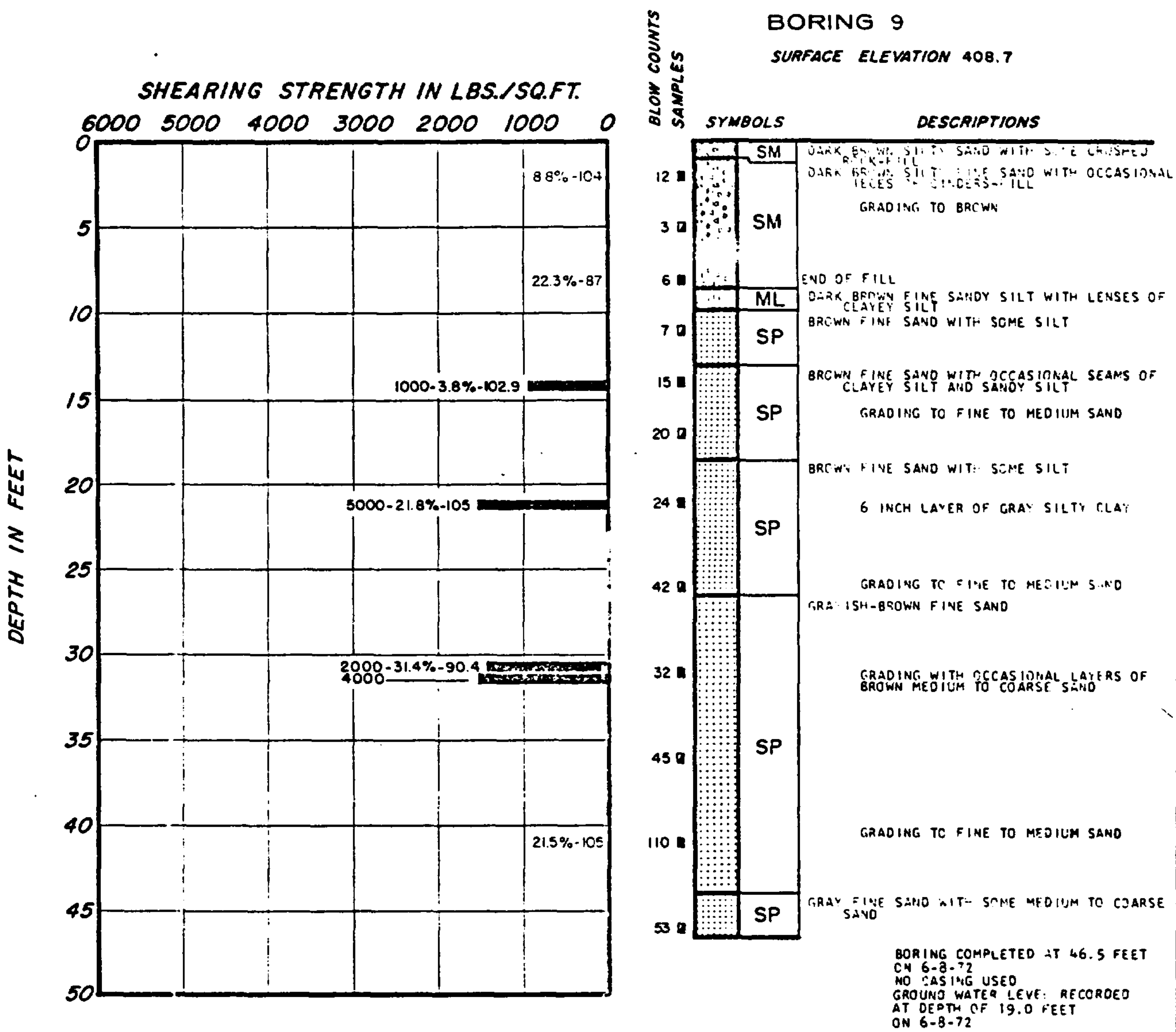
THE GROUND WATER LEVEL STABILIZED AT A DEPTH OF 20.7 FEET BELOW THE GROUND SURFACE ON 6-22-72

OBSERVATION WELL INSTALLATION:
ONE INCH I.D. PVC PIPE WAS INSTALLED TO A DEPTH OF 53 FEET. HOLES, APPROXIMATELY ONE-EIGHTH INCH IN DIAMETER, WERE DRILLED IN THE BOTTOM FIVE FEET OF PIPE. THE BORING WAS FLUSHED WITH CLEAR WATER AND BACKFILLED WITH GRANULAR MATERIAL TO THE GROUND SURFACE.

LOG OF BORINGS

DAMES & MOORE

PLATE A-1E



LOG OF BORINGS

DAMES & MOORE

PLATE A-1F

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GRAPH SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
				GP	POORLY-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING NO. 4 SIEVE	CLEAN SAND (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
				SP	POORLY-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND-SILT MIXTURES
				SC	CLAYEY SANDS, SAND-CLAY MIXTURES
FINE GRAINED SOILS MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

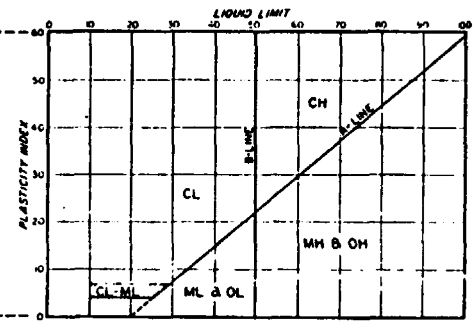
FOR LABORATORY CLASSIFICATION OF FINE-GRAINED SOILS

SOIL CLASSIFICATION CHART

MATERIAL SIZE		PARTICLE SIZE			
		LOWER LIMIT		UPPER LIMIT	
		MILLIMETERS	SIEVE SIZE*	MILLIMETERS	SIEVE SIZE*
SAND	FINE	0.074	#200	0.42	#40
	MEDIUM	0.42	#40	2.00	#10
	COARSE	2.00	#10	4.76	#4
GRAVEL	FINE	4.76	#4	19.1	3/4"
	COARSE	19.1	3/4"	76.2	3"
COBBLES		76.2	3"	304.8	12"
BOULDERS		304.8	12"	914.4	36"

* U.S. STANDARD * CLEAR SQUARE OPENINGS

GRADATION CHART



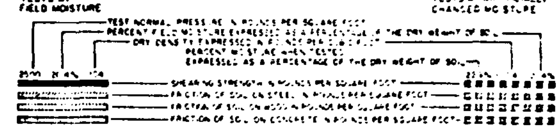
PLASTICITY CHART

NOTES:

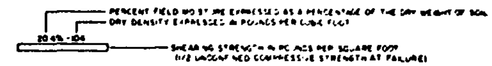
1. DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE CLASSIFICATIONS.
2. WHEN SHOWN ON THE BORING LOGS, THE FOLLOWING TERMS ARE USED TO DESCRIBE THE CONSISTENCY OF COHESIVE SOILS AND THE RELATIVE COMPACTNESS OF COHESIONLESS SOILS.

COHESIVE SOILS	APPROXIMATE SHEARING STRENGTH (KSF)	COHESIONLESS SOILS	
VERY SOFT	LESS THAN .25	VERY LOOSE	THESE ARE USUALLY BASED ON AN EXAMINATION OF SOIL SAMPLES, PENETRATION RESISTANCE, AND SOIL DENSITY DATA
SOFT	.25 TO .5	LOOSE	
MEDIUM STIFF	0.5 TO 1.0	MEDIUM DENSE	
STIFF	1.0 TO 2.0	DENSE	
VERY STIFF	2.0 TO 4.0	VERY DENSE	
HARD	GREATER THAN 4.0		

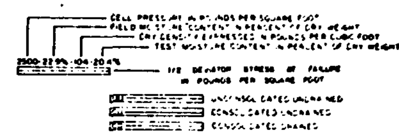
KEY TO TEST DATA



DIRECT SHEAR AND FRICTION TESTS



UNCONFINED COMPRESSION TESTS



TRIAXIAL COMPRESSION TESTS

YIELD, PEAK OR ULTIMATE STRENGTHS ARE IDENTIFIED ON SHEAR TEST DATA ON THE BORING LOGS AS FOLLOWS

- • YIELD STRENGTH
- •• PEAK STRENGTH
- ••• ULTIMATE STRENGTH

SHEAR TEST RESULTS

- INDICATES UNDISTURBED SAMPLE
- INDICATES DISTURBED SAMPLE
- INDICATES SAMPLING ATTEMPT WITH NO RECOVERY
- INDICATES LENGTH OF CORING RUN

NOTE
DEFINITIONS OF ANY ADDITIONAL DATA REGARDING SAMPLES ARE ENTERED ON THE FIRST LOG ON WHICH THE DATA APPEAR

SAMPLES

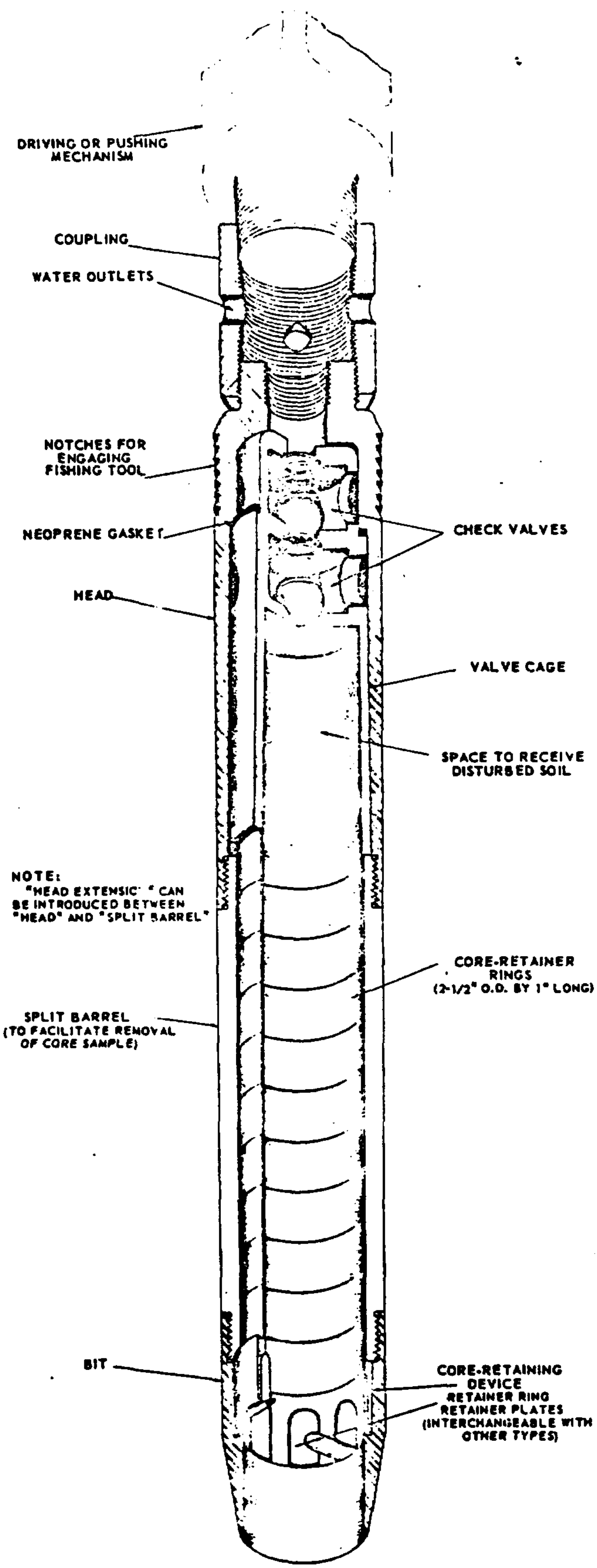
UNIFIED SOIL CLASSIFICATION SYSTEM AND KEY TO TEST DATA

DAMES & MOORE

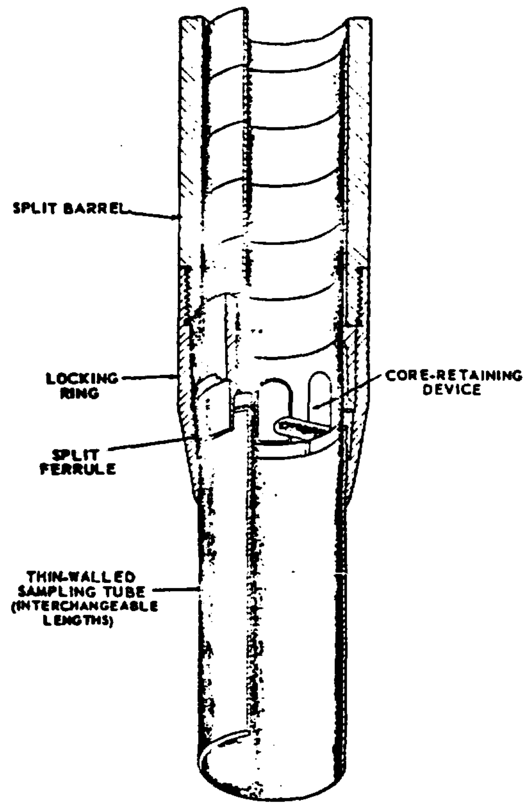
PLATE A-2

SOIL SAMPLER TYPE U

FOR SOILS DIFFICULT TO RETAIN IN SAMPLER
U. S. PATENT NO. 2,318,062



ALTERNATE ATTACHMENTS



DAMES & MOORE
APPLIED EARTH SCIENCES

REVISIONS
BY ____ DATE ____ TO GO ____
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FILE ____

BY ____ DATE ____
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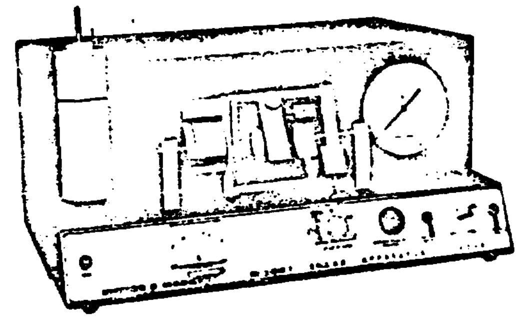
Method Of Performing Direct Shear and Friction Tests

Direct shear tests are performed to determine the shearing strengths of soils. Friction tests are performed to determine the frictional resistances between soils and various other materials such as wood, steel, or concrete. The tests are performed in the laboratory to simulate anticipated field conditions.



DIRECT SHEAR TESTING
& RECORDING APPARATUS

Each sample is tested within three brass rings, two and one-half inches in diameter and one inch in length. Undisturbed samples of in-place soils are tested in rings taken from the sampling device in which the samples were obtained. Loose samples of soils to be used in constructing earth fills are compacted in rings to predetermined conditions and tested.

Direct Shear Tests

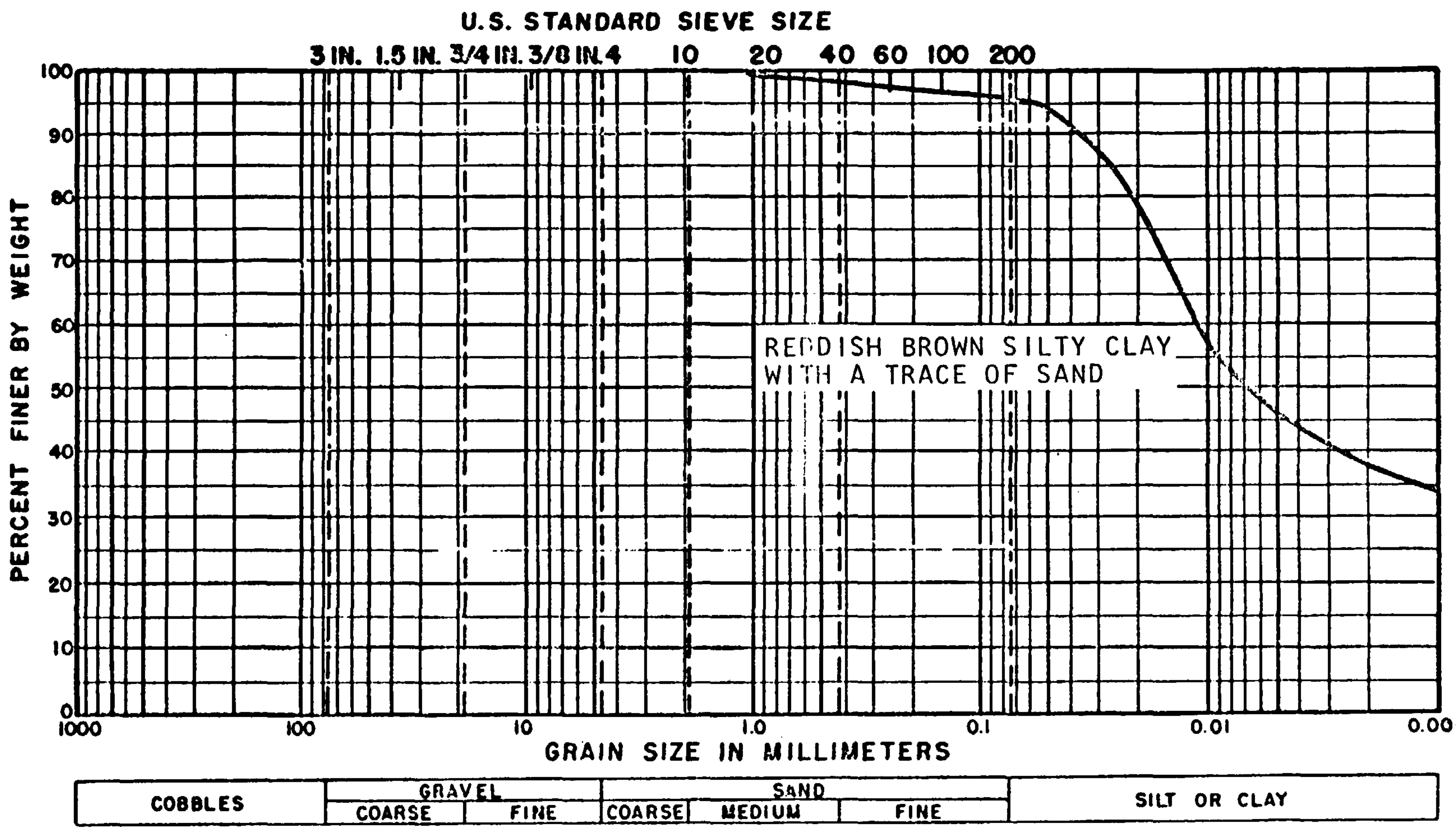
A three-inch length of the sample is tested in direct double shear. A constant pressure, appropriate to the conditions of the problem for which the test is being performed, is applied normal to the ends of the sample through porous stones. A shearing failure of the sample is caused by moving the center ring in a direction perpendicular to the axis of the sample. Transverse movement of the outer rings is prevented.

The shearing failure may be accomplished by applying to the center ring either a constant rate of load, a constant rate of deflection, or increments of load or deflection. In each case, the shearing load and the deflections in both the axial and transverse directions are recorded and plotted. The shearing strength of the soil is determined from the resulting load-deflection curves.

Friction Tests

In order to determine the frictional resistance between soil and the surfaces of various materials, the center ring of soil in the direct shear test is replaced by a disk of the material to be tested. The test is then performed in the same manner as the direct shear test by forcing the disk of material from the soil surfaces.

REVISIONS BY ____ DATE ____ FILE ____ BY ____ DATE ____ CHECKED BY ____



DAMES & MOORE

PARTICLE SIZE DISTRIBUTION

PLATE A-5A

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BY DATE
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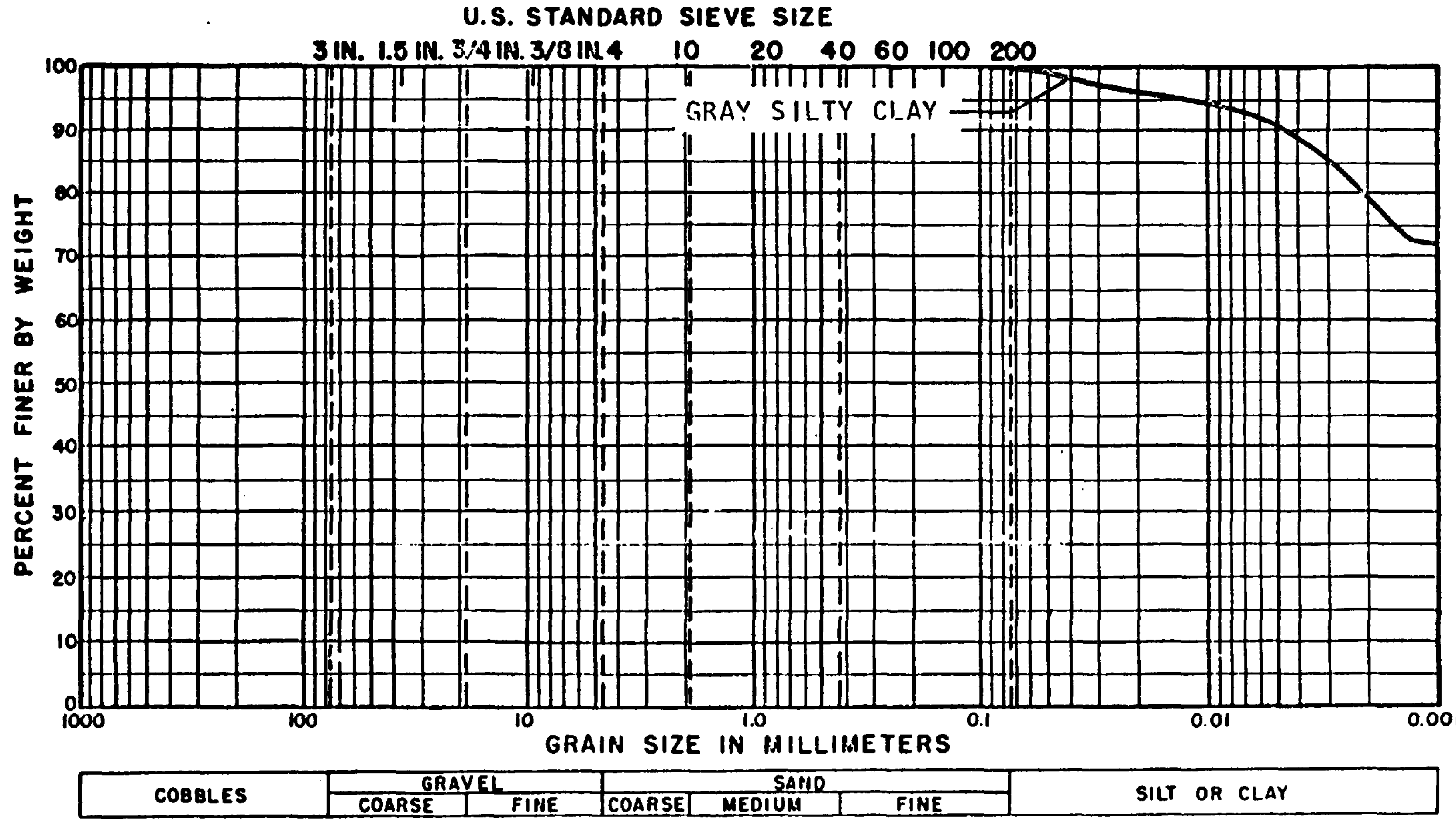
REVISIONS
BY DATE
BY DATE
PLATE OF



PARTICLE SIZE DISTRIBUTION

DAMES & MOORE

PLATE A-5B

REVISIONS BY ______ DATE ______

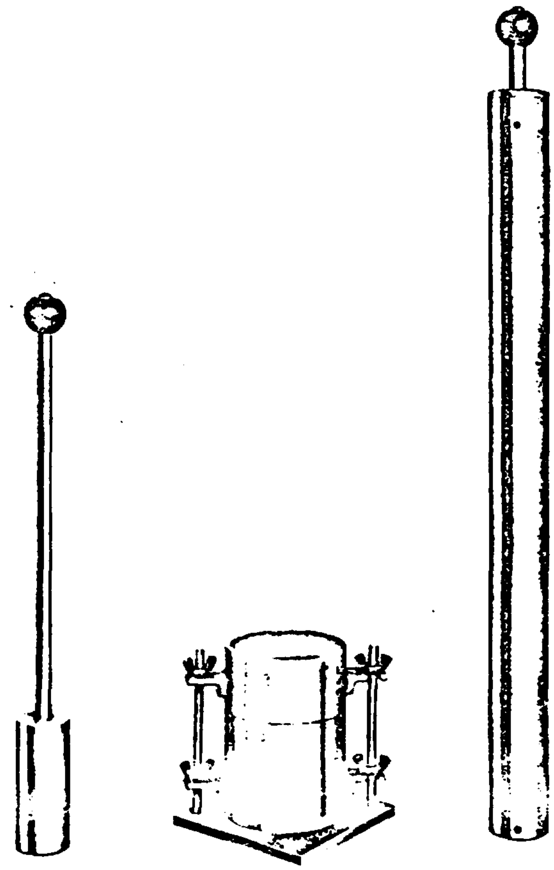
FILE ______

BY ______ DATE ______
CHECKED BY ______

METHOD OF PERFORMING COMPACTION TESTS
(STANDARD AND MODIFIED A.A.S.H.O. METHODS)

IT HAS BEEN ESTABLISHED THAT WHEN COMPACTING EFFORT IS HELD CONSTANT, THE DENSITY OF A ROLLED EARTH FILL INCREASES WITH ADDED MOISTURE UNTIL A MAXIMUM DRY DENSITY IS OBTAINED AT A MOISTURE CONTENT TERMED THE "OPTIMUM MOISTURE CONTENT," AFTER WHICH THE DRY DENSITY DECREASES. THE COMPACTION CURVE SHOWING THE RELATIONSHIP BETWEEN DENSITY AND MOISTURE CONTENT FOR A SPECIFIC COMPACTING EFFORT IS DETERMINED BY EXPERIMENTAL METHODS. TWO COMMONLY USED METHODS ARE DESCRIBED IN THE FOLLOWING PARAGRAPHS.

FOR THE "STANDARD A.A.S.H.O." (A.S.T.M. D698-58T & A.A.S.H.O. T99-57) METHOD OF COMPACTION A PORTION OF THE SOIL SAMPLE PASSING THE NO. 4 SIEVE IS COMPACTED AT A SPECIFIC MOISTURE CONTENT IN THREE EQUAL LAYERS IN A STANDARD COMPACTION CYLINDER HAVING A VOLUME OF 1/30 CUBIC FOOT, USING TWENTY-FIVE 12-INCH BLOWS OF A STANDARD 5-1/2 POUND RAMMER TO COMPACT EACH LAYER.



SOME APPARATUS FOR PERFORMING COMPACTION TESTS
Shows, from left to right, 5-1/2 pound rammer (sleeve controlling 12" height of drop removed), 1/30 cubic-foot cylinder with removable collar and base plate, and 10 pound rammer within sleeve.

IN THE "MODIFIED A.A.S.H.O." (A.S.T.M. D-1557-58T & A.A.S.H.O. T 180-57) METHOD OF COMPACTION A PORTION OF THE SOIL SAMPLE PASSING THE NO. 4 SIEVE IS COMPACTED AT A SPECIFIC MOISTURE CONTENT IN FIVE EQUAL LAYERS IN A STANDARD COMPACTION CYLINDER HAVING A VOLUME OF 1/30 CUBIC FOOT, USING TWENTY-FIVE 18-INCH BLOWS OF A 10-POUND RAMMER TO COMPACT EACH LAYER. SEVERAL VARIATIONS OF THESE COMPACTION TESTING METHODS ARE OFTEN USED AND THESE ARE DESCRIBED IN A.A.S.H.O. & A.S.T.M. SPECIFICATIONS.

FOR BOTH METHODS, THE WET DENSITY OF THE COMPACTED SAMPLE IS DETERMINED BY WEIGHING THE KNOWN VOLUME OF SOIL; THE MOISTURE CONTENT, BY MEASURING THE LOSS OF WEIGHT OF A PORTION OF THE SAMPLE WHEN OVEN DRIED; AND THE DRY DENSITY, BY COMPUTING IT FROM THE WET DENSITY AND MOISTURE CONTENT. A SERIES OF SUCH COMPACTIONS IS PERFORMED AT INCREASING MOISTURE CONTENTS UNTIL A SUFFICIENT NUMBER OF POINTS DEFINING THE MOISTURE-DENSITY RELATIONSHIP HAVE BEEN OBTAINED TO PERMIT THE PLOTTING OF THE COMPACTION CURVE. THE MAXIMUM DRY DENSITY AND OPTIMUM MOISTURE CONTENT FOR THE PARTICULAR COMPACTING EFFORT ARE DETERMINED FROM THE COMPACTION CURVE.

TABLE 2

RECOMMENDED UNIT OPERATIONS

1. <u>Trash Screens</u>
   Use existing screens - repairs necessary
   Type - Vertical wooden bars
   Number of Screens - 3
   Openings - 2 inches
   Type of Trash - Agglomerated rubber and residue, wood, rags, hoses
   Volume of Trash - 10 cubic feet/day, maximum
   Trash removal - Mechanical, manually activated
   Trash disposal - Landfill

2. <u>Pumping Station</u>
   Use existing station - modifications and repairs necessary
   Capacity to pump to treatment plant -
   maximum - 11.5 MGD, 8050 gpm, 18 cfs
   average - 8.75 MGD, 6120 gpm, 13.7 cfs
   Capacity to pump to storage lagoon or storm water clarifier
   maximum - 71 MGD, 49,600 gpm, 110.5 cfs

3. <u>Storm Water Storage Lagoon</u>

   Design Capacity:
   800,000 gallons Storm
   300,000 gallons Peaks
   1,100,000 gallons Total

   Operating (Design):
   Water Depth = 10 feet
   Width = 141 feet) (mean dimensions)
   Length= 160 feet)
   Freeboard = 3 feet

   Embankment Slopes:
   Interior: 3 horizontal to 1 vertical
   Exterior: 3 horizontal to 1 vertical

   Embankment Thickness: 8 feet at top, minimum

Embankment Height: 13 feet from bottom of lagoon

Top Interior Dimensions: Length = 178 feet
Width = 159 feet

Bottom Interior Dimensions: Length = 100 feet
Width = 81 feet

Total Basin Volume = 223,000 cubic feet

Liner: Impervious to water

Solids Removal: Front-end-loading bulldozer to landfill

Estimated Yearly Volume Processed: 66,000,000 gallons

Estimated Yearly Solids Retention: 1,330,000 gallons

Frequency of Cleaning: 4 times/year to maintain 75% operating capacity

Inlet: Baffled

Outlet: Float controlled with flexible arm; "Stop" mechanism to prevent sludge draw-off

4. Storm Water Clarifier

Purpose: To provide primary clarification to storm waters in excess of treatment plant design flow after storage of "First Flush"

Design Overflow Rate: 2000 gal./ft.^{2}-day, maximum

Weir Overflow Rate: 15,000 gal/lin.ft.-day, maximum

Design Flow Rate: 71.5 MGD, maximum

Surface Area (Working): 35,750 square feet

Working Depth: 12 feet

Freeboard: 3 feet

Embankment Slopes: Interior: 3 horizontal to 1 vertical
3 horizontal to 1 vertical

Embankment Thickness: 8 feet at top, minimum

Embankment Height: 15 feet from clarifier bottom

Total Basin Volume: 566,000 cubic feet

Basin Working Volume: 308,000 cubic feet

Liner: Impervious to water (ground water relief valves required to prevent damage to liner when drained.)

Scum Removal: Manually tiltable trough with drain to sump pump to central scum handling facility.

Estimated Average Volume
Processed: 40,000,000 gal./year
90,000,000 gal./year

Total Clarifier Working Volume = 2,300,000 gallons
(308,000 cubic feet)

Influent Suspended Solids = 100 mg/l average

Estim. % Solids Removal = 70%

Underflow Suspended Solids = 8%

Vol. Suspended Solids Retention = 40,000 gal/year aver. - 90,000 gal/year maximum

Demucking Frequency = One every 72 months (to maintain ~75% or more working capacity)

5. Grit Chamber
Type - rectangular
Number of Chambers - 2
Design Flow - 11.5 MGD
Design Flow Velocity - 1 foot/second
Grit Characteristics
10 - 94% organics
Settling rate 4 feet, minimum
Specific gravity average ~1.5-2.0
Overflow rate 42,800 gallons/day/feet^2
Flow Control - Parshall Flume
Volume of Grit -
Maximum - 520 cubic feet/day
Average - 260 cubic feet/day
Grit Removal - mechanical - continuous
Grit Disposal - landfill
Dimensions - single chamber 56 feet x 5 feet 4 inches
Detention Time
Working - 37 seconds
Total - 56 seconds
Volume - 333 cubic feet, each
Total Area Requirements: 90 feet x 10 feet (including inlet and outlet)

6. Neutralization

A. Chambers
Number required - 2
Shape - cubicle
Detention Time - 10 minutes at design flow (11.5 MGD)
Working Volume - 4,050 feet^3 (30,300 gallons)
Interior Working Dimensions - 16 feet x 16 feet x 16 feet
Approximate Exterior Dimensions - 18.5 feet x 18.5 feet x 18.5 feet
Baffles - baffles to prevent vortexing and influent short circuiting

Agitation - 35 horsepower per chanber, turbine
type mixers

Type of Control - feedback pH recorder control - Control valves should have linear trim with positioners

Neutralization - (Chemical Usage, Chemical Storage, Slaking, Feeding)

Waste Acidity - Average 100,500 pounds/day ($CaCO_3$)
Maximum 426,000 pounds/day ($CaCO_3$)

Lime Utilization - At average - 50%
At maximum - 75%

Neutralizing Agent - High Calcium Quicklime

Design Feed Rate Average - 200,000 pounds/day ($CaCO_3$)
- 112,000 pounds/day (CaO)
Maximum - 640,000 pounds/day ($CaCO_3$)
- 410,000 pounds/day (CaO)

Storage Capacity - 7 days based on average usage

Number of Storage Silos - 4

Silo Capacity - 34,000 gallons (each)

Feeder Capacity - Maximum - 90,000 pounds CaO/day(each)
Range - 15,000-90,000 lbs CaO/day

Number of Slakers - 2

Capacity of Slakers - Maximum-180,000 lbs CaO/day(each)
Range-15,000-100,000 lbs CaO/day (each)

7. Flocculation

A. Chamber

Tank Shape - rectangular with rounded fillets along the bottom sidewall. Sidewall depth - 10 feet

Paddles - four bladed paddles running the width of the chamber with a tip speed of 2 feet/second
detention time 15 minutes

Baffles - baffling between flocculation and sedimentation

Dimensions - 75 feet x 8 feet x 10 feet

B. Polyelectrolyte

Polyelectrolyte - Atlas 2A2

Addition Range - from 0.25 mg/l at 8.75 MGD to 1.5 mg/l at 11.5 MGD or 18.3 lb/day - 144 lb/day

Normal Operation - 0.5 mg/l at 8.75 MGD

Solution Concentration - 0.4% solution

8. Solids and Scum Removal

The existing facilities will be used with required repairs or modifications.

9. Sludge Handling & Vacuum Filtration

Sludge Handled - 79,000 lbs/day

Filter Loading Rate - 2.5 lbs/ft^2/hr.

Period of Operation - 24 hours/day

Total Filter Area - 1250 square feet

Space Required - 56 feet x 49 feet for two filters
- 56 feet x 24 feet for future expansion

Ultimate Disposal - Landfill

10. Flow Measurement and Sampling

Flow measurement - Parshall Flume

Sampling - Continuous, flow proportioned sample for -

1. Raw waste before neutralization
2. Effluent from clarifiers

APPENDIX B

"FIRST FLUSH" CALCULATIONS

STORM WATER RUNOFF-BASES FOR CALCULATION OF FIRST FLUSH VOLUME

A. Sewer Contamination Build-Up

It is assumed that the Village of Sauget's main sewers have no appreciable contaminant build-up because of the high, consistent flow resulting in adequate scour velocities to prevent any significant build-up of deposits in the sewers. This high scour condition is not the case in larger cities where the flows are not great enough during dry weather to allow adequate scour velocities.

B. Above Ground Contamination

Contaminants present on streets, buildings, equipment and grounds will add an unknown amount of contamination to storm runoff. The contaminants washed off by the rain water would be expected to be in concentrations below the wastewater levels, thus storm runoff would act as a diluent even during the first period of the storm.

In any event, potential areas of rain water contamination are limited to the acreage bounded by the darkened lines on the attached map (note Figure 3). Areas will include 0.5 A, B, 0.5 C, D, E, F, G, H, M, N, O, Q, R, S, 0.5 T, U, V, W, X, Y and AA totaling 185 acres or 8.059 million ft^2 (note Table 27).

C. Definition of First Flush

1. It is assumed that the major portion of any possible above ground contaminants will be carried off in the first 0.2" of rainfall.

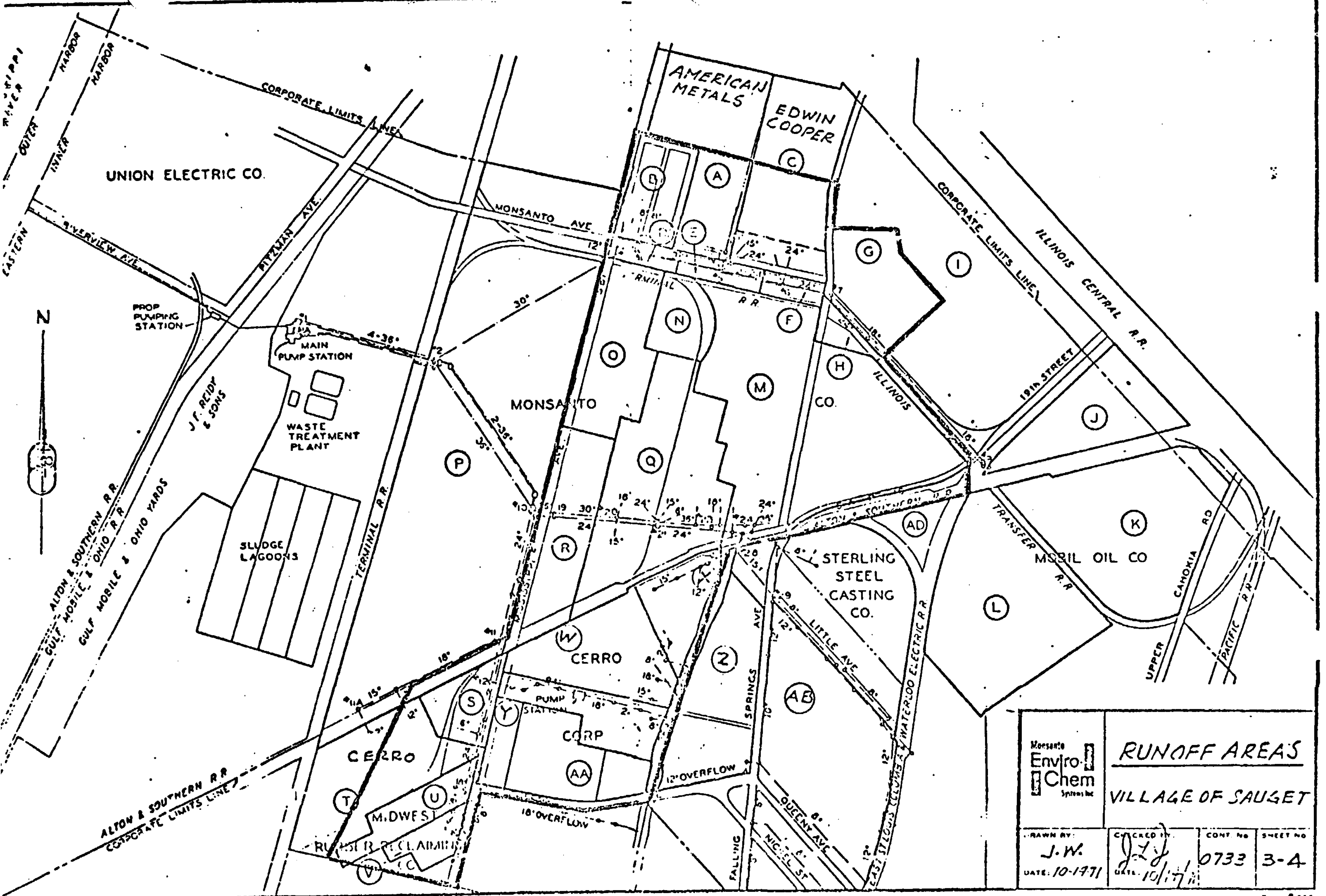
2. Average runoff coefficient estimated to be 0.7.

3. First flush volume = V_{FF}

$$V_{FF} = \frac{185 \text{ acres} \times 43{,}560 \text{ ft}^2/\text{acre} \times 0.2 \text{ in.} \times 0.7 \times 7.48}{12 \text{ in./ft} \qquad (\text{gal/ft}^3)^{-1}}$$

V_{FF} = 800,000 gal.

4. The calculated volume of all main sewers in the potential contaminant area is 510,000 gal; thus, the surface wash will provide a volume sufficient to flush the main sewer approximately 1.6 times.



UNION ELECTRIC CO.
CORPORATE LIMITS LINE
AMERICAN METALS
EDWIN COOPER
MONSANTO AVE.
RIVERVIEW AVE.
PITZMAN AVE.
PROP PUMPING STATION
MAIN PUMP STATION
WASTE TREATMENT PLANT
SLUDGE LAGOONS
MONSANTO
CO.
TERMINAL R.R.
ALTON & SOUTHERN R.R.
GULF MOBILE & OHIO R.R.
GULF MOBILE & OHIO YARDS
J.F. REIDY & SONS
ILLINOIS CENTRAL R.R.
19th STREET
STERLING STEEL CASTING CO.
MOBIL OIL CO
TRANSFER R.R.
CAHOKIA RD
UPPER
PACIFIC R.R.
CERRO
CERRO CORP
PUMP STATION
LITTLE AVE.
SPRINGS AVE.
QUEENY AVE.
NICKEL ST
FALLING
EAST ST. LOUIS, COLUMBIA & WATERLOO ELECTRIC R.R.
12" OVERFLOW
18" OVERFLOW
MIDWEST RUBBER RECLAIMING CO
ALTON & SOUTHERN R.R. CORPORATE LIMITS LINE
N
Monsanto Enviro-Chem Systems Inc
RUNOFF AREAS
VILLAGE OF SAUGET
DRAWN BY: J.W.
DATE: 10-1-71
CHECKED BY:
CONT. No 0733
SHEET No 3-4
ENG #365

Figure 3

Table 27

RUNOFF CALCULATIONS

Section	Area (Acres)	Runoff Coefficient	Flow (cfs)	Remarks
A	17	--	1.2	Balance to Seepage Pond
B	7	0.7	7.7	0.7 cfs from D
C	13.3	0.7	14.6	0.6 cfs from E, 0.9 cfs from F
D	2.0	0.7	0	0.9 cfs to B, 1.0 cfs to O
E	2.8	0.7	0	0.7 cfs to A M, & N; 0.6 cfs to C
F	1.8	0.7	0	0.9 cfs to C & M
G	10	0.9	9.8	Parking Area
H	2.0	0.7	1.9	
I	--	--	--	Agricultural Area
J				From Pumping
K			16.7	Station, Maximum
L				Pumping Capacity
M	45	0.7	45.6	0.7 cfs from E; 0.9 cfs from F
N	5	0.7	5.6	0.7 cfs from E
O	14	0.7	14.7	1.0 cfs from D
P	---	---	---	Agricultural Area

Runoff Calculations (cont'd)

Section	Area (Acres)	Runoff Coefficient	Flow (cfs)	Remarks
Q	27	0.7	26.5	
R	14	0.7	13.7	Minor Flooding Allowed
S	--	--	1.0	Maximum Outlet Capacity
T	--	--	--	To Seepage Pond
U V	8.1	0.7	7.9	
W	11.8	0.7	11.5	
X	10.0	0.7	9.8	
Y	3.0	0.7	2.9	
Z	16.7	0.2	4.6	
AA	6.0	0.7	5.9	
AB	5	0.7	4.9	Street and Residential Runoff
Total			206.5	

5. V_{FF} = first flush storm water surge capacity.

D. Arrival Lag of First Flush

The arrival lag of the first flush water to the treatment plant will be governed by the surface runoff time and the sewer retention time.

1. It is estimated that the runoff to sewer collection boxes will flow an average of 500 feet to the main sewers at an average velocity of of 2 ft/sec. (120 ft/min.)

$$\frac{500 \text{ ft}}{120 \text{ ft/min}} = 4.2 \text{ min. surface runoff time.}$$

2. Sewer retention time is based upon a full-flow velocity of 5 ft/sec. (300 ft/min.). 4-36" sewers flowing at 128.5 cfs = $4 \left(\frac{\pi D^2}{4}\right)$ = sewer area = $\pi(3)^2 = 28.3 \text{ ft}^2$, and $\frac{128.5 \text{ cfs}}{28.3 \text{ ft}^2} = 5$ ft/sec.

Since the longest main sewer run in the potential contaminant area is 4,300 ft, the expected sewer retention time is $\frac{4300 \text{ ft}}{300 \text{ ft/min}} = 14.3$ min.

3. Therefore, the total delay of the arrival of the first 0.2" rainfall in reaching the treatment facility would be 14.3 + 4.2 = 18.5 min.

E. <u>Pumping Times</u>

1. Minimum pumping time - In the case of an intense storm (i.e., 2"/hour for 30 min*) it is assumed that a full-flow condition (128.5 cfs) would be reached in the sewer quite rapidly. Flows of this order of magnitude would cause sewer back-up and overflow to surge ponds. In such a condition, holding lagoon capacity for storm water would be reached in approximately 16 min. assuming treatment plant design flow of 8050 gpm (18 cfs) and pumping capacity to the lagoon of 49,600 gpm (110.5 cfs).

2. Normal pumping time - "Normal" pumping time is defined as the time required to reach storm water holding capacity of 800,000 gal. The flows pumped to the holding lagoon or the bypass primary treatment facility would be only those flows exceeding design flows. All flows not exceeding design flow (rainfall - present or not) will be accepted as normal raw waste to the treatment system.

*See attached rainfall intensity - frequency curve.

ft^2 day. The treatment plant will normally be able to handle 0.8 MGD in storage and 2.75 MGD in treatment capacity above the average dry weather flow.

It should be understood that the surge capacity located in the areas along 19th street and in Dead Creek will handle sewer back ups so that after these ponds have drained into the sewers; after cessation of maximum storm flow, greater than 8.4 times the normal daily dry weather flow will have been treated.

F. Treatment of First Flush

The treatment system design capacity will be adjusted to accept the first flush water volume of 800,000 gallons during the 48 hour period immediately following cessation of storm flow conditions. In the event storm conditions are resumed during this 48 hour period, all flow exceeding design will be considered post-first flush and diverted to the storm water primary system or bypassed if in excess of this storm water primary treatment system capacity. Because the average flow is predicted to be 8.75 MGD compared to the 11.5 MGD design flow, much less than 48 hours may be expected for bleeding back the first flush water.

G. Treatment of Storm Bypass Flows

It has been assumed that primary treatment of storm bypass flows (under Part VI, Section 602, paragraph C of the Illinois State Effluent Criteria) will consist of a settling basin with a design flow of 71×10^6 gallons/day (49,600 gal/min or 110.5 ft^3/sec). This value is equal to the maximum calculated sewer capacity minus the MGD treated in the Village plant or 8.2 times the normal dry weather flow expected in 1974. The design overflow rate of the storm water clarifier will be 2000 gal/

Materials of Construction Tested For Chemical Plant Waste Disposal Facilities

By OLIVER W. SIEBERT

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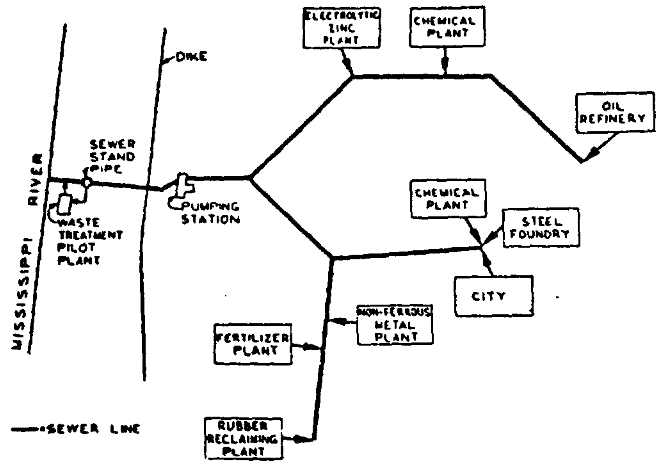

Figure 1—General layout of Monstanto, Illinois, sewerage system.

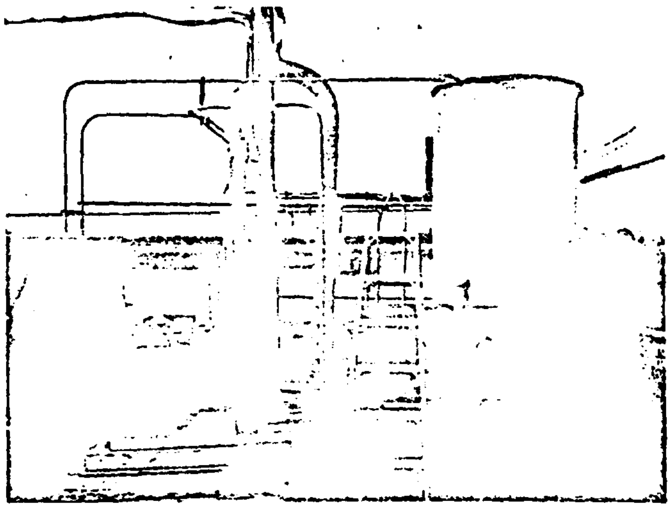

Figure 2—Wastes, directly from sewer, are sampled at pump tank.

Materials of Construction Tested For Chemical Plant Waste Disposal Facilities*

By OLIVER W. SIEBERT

Introduction

THE PROBLEM of disposing of industrial wastes has received much public attention during the past 15 years. Historically, the desire for laws regulating stream pollution has been the province of state and local sportsmen and conservation groups. The Water Pollution Control Act of 1956 allows the federal government to join with state and local agencies.

Monsanto Chemical Company, as most industries, had long accepted its responsibilities and directed efforts in the preventive field of in-plant waste reduction.[1] Since 1959 it has operated a small activated sludge pilot plant and oxidation pond to determine the manner in which company wastes could be treated on a continuous basis and to collect design data.[1,2]

This article will discuss the corrosion investigation conducted in this pilot plant, report test data and present the range of acceptable construction materials for all unit operations of a chemical plant waste disposal facility.

Environment

The W. G. Krummrich Plant of Monsanto is located south of East St. Louis in Monsanto, Iillinois. All its wastes, industrial and sanitary, are discharged to the Mississippi River through the Monsanto village sewerage system. Two main trunk lines which pass through the plant also carry wastes from six other industries and the sanitary sewage from the village of Monsanto.

The Krummrich Plant produces basic chemicals such as hydrochloric, phosphoric and sulfuric acids, chlorine and caustic, herbicides, insecticides, oil additives and intermediates. Approximately 100 different items are produced using a like number of different raw materials.

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About the Author

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Abstract

Data are reported on the results of tests to determine the range of acceptable construction materials for all unit operations of a chemical plant waste disposal facility. The investigation presented illustrates the corrosion problems encountered in the biological treatment of chemical wastes, stream pollution abatement. The tests were conducted in a pilot plant installed to study the manner in which wastes could be treated on a continuous basis. This activated sludge plant and oxidation pond handled the liquid wastes from a major chemical plant along with those from an oil refinery, zinc plant, casting plant, metals reclaiming operation, rubber reclaiming plant, fertilizer plant and domestic sewage. The corrosion study, directed toward criterion requirements for the design and economical maintenance of a full scale, operational secondary waste treatment plant, concludes with recommendations for construction materials. 2.3.8

TABLE 1—Composition of Combined Monsanto Village Sewage Before and After Activated Sludge Treatment

Property	Typical Data of 24-hour Composite Sample Removed From Main Sewer	Typical Data of Effluent Sample Removed After Final Settling Tank
pH	3.0	7.9
Settleable Solids	2.5 mg/L	0.9 mg/L
Suspended Solids	150 ppm	112 ppm
Dissolved Solids	2500 ppm	2500 ppm
Chlorides	600 ppm	600 ppm
Total Acid	300 ppm	....
COD	700 ppm	221 ppm
BOD	300 ppm	90 ppm
Phenol	50 ppm	4 ppm
Oil	25 ppm	4 ppm
Threshold Odor No.	300	20
Flow	36 x 10⁶ gal/day; 2-3 ft/sec.	30 gal/min; 5.2 ft/sec.

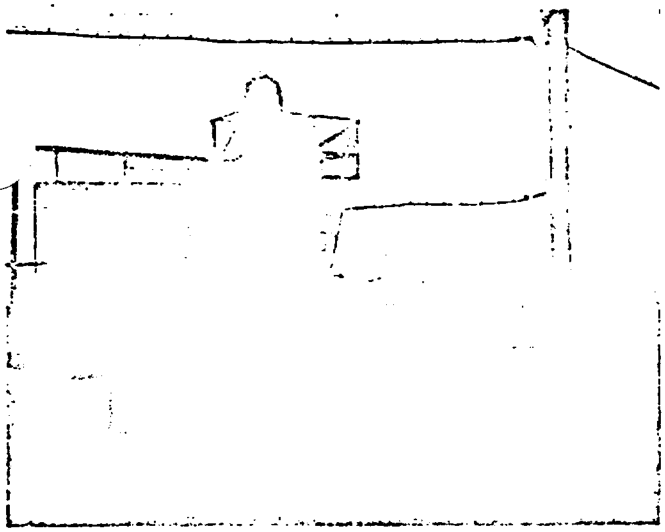

Figure 3—Overall view of waste treatment pilot plant. Wooden tanks on right are neutralizer and hold tanks. Preliminary and final settlers are at left center. Tank at left is aeration tank.

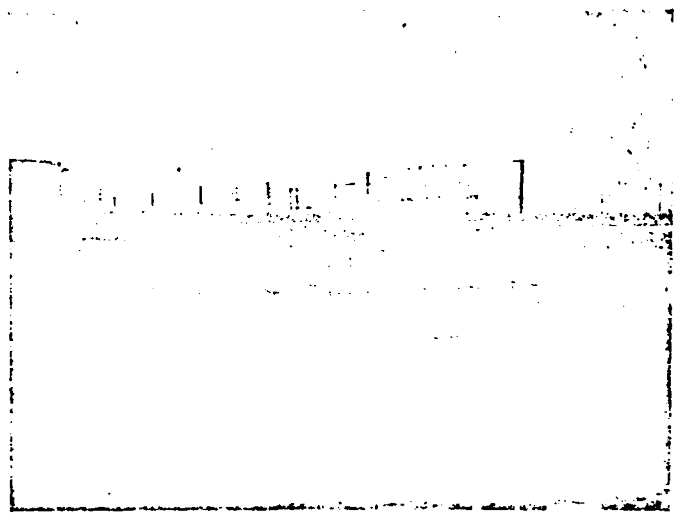

Figure 4—Oxidation pond shown here has an area of 1/10 acre and a depth of 3 feet. Influent is at the left end and overflow at the right.

Wastes from these operations along with wastes from an oil refinery, zinc plant, casting plant, metal reclaiming operation, rubber reclaiming plant, fertilizer plant and domestic sewage make up the composition of the wastes in the village sewers. All sewers join before reaching the Mississippi River and discharge through a single outfall.[1] Figure 1 shows the general layout of the Monsanto village sewerage system.

A typical range of composition of the system waste is shown in Table 1.[1,3] Laboratory determinations were made each day on a 24-hour composite sample for the following: pH, settleable solids, suspended solids, dissolved solids, chlorides, total acid, chemical oxygen demand (COD), biological oxygen demand (BOD), phenol, oil and threshold odor number.[1] Figure 2 shows the sampling station.

Treatment Theory

Activated sludge plants are a form of aerobic biological treatment of organic waste materials. Liquid waste is aerated by bubbling air through the liquid. Microorganisms form flocculent masses of aerobic bacteria, called activated sludge, that are suspended in the liquid.

In plant operation, sewage is initially presettled. The clarified effluent is contacted with activated sludge microorganisms while being vigorously aerated (which forms more activated sludge). The mixture is gravity separated, with sludge from this clarifier recycled as seed to the biological activity in the aerator. There are at least two reactions that occur. Clarification by adsorption takes about 30 minutes. Oxidation of organic matter in solution and in colloidal/suspended form, after adsorption, takes several hours.[4]

Lagooning is the simplest method of aerobic biological treatment of waste. Organisms usually develop naturally, although seeding of the pond may be accomplished with domestic sewage or

TABLE 2—Results of Corrosion Tests in Main Sewer Pipe and 37 Foot Standpipe After 1819 Hours Exposure[a,b]

Sample Identification	Location of Sample In Standpipe	Average Corrosion Rate	Remarks
Steel	Bottom	55 mpy	Concentration cell, cratering
	10′	10 mpy	Concentration cell, pitting
	20′	3 mpy	Pitting, rusting
	30′	10 mpy	Pitting, rusting
Cast Iron	Bottom	14 mpy	Graphitization
	10′	3 mpy	Graphitization
	20′	5 mpy	Concentration cell, pitting
	30′	9 mpy	Pitting, rusting
Ductile Cast Iron	Bottom	35 mpy	Severe pitting
	10′	4 mpy	Severe pitting
	20′	2 mpy	Severe pitting
	30′	2 mpy	Severe pitting
Ni Resist I	Bottom	4 mpy	Pitting, intergranular etch
	10′	1 mpy	Pitting
	20′	<1 mpy	Pitting
	30′	4 mpy	Severe pitting
Ni Resist II	Bottom	6 mpy	Pitting, intergranular etch
	10′	1 mpy	Pitting
	20′	<1 mpy	Pitting, intergranular etch
	30′	2 mpy	Severe pitting, intergranular etch, rusting
Chemical Lead	Bottom	<1 mpy	Pitting
	10′	<1 mpy	Pitting
	20′	1 mpy	Pitting
	30′	<1 mpy	Pitting
80-20 Cu-Ni	Bottom	<1 mpy	Pitting
	10′	1 mpy	Pitting
	20′	<1 mpy	Pitting
	30′	2 mpy	Pitting
2SH Aluminum	Bottom	40 mpy	Severe shallow pitting
	10′	<1 mpy	Light shallow pitting
	20′	<1 mpy	Light shallow pitting
	30′	<1 mpy	Light shallow pitting
201 Stainless Steel	Bottom	1 mpy	General light pitting, locally severe
	10′	<1 mpy	General light pitting, locally severe
	20′	<1 mpy	General light pitting, locally severe
	30′	<1 mpy	General light pitting, locally severe
202 Stainless Steel	Bottom	3 mpy	Scattered locally severe pitting
	10′	<1 mpy	General light pitting, scattered deep pits
	20′	<1 mpy	General light pitting, scattered deep pits
	30′	<1 mpy	General light pitting, scattered deep pits
304 Stainless Steel	Bottom	<1 mpy	Light pitting, intergranular etch
	10′	<1 mpy	Light pitting to cratering
	20′	<1 mpy	Light pitting, scattered deep pits
	30′	<1 mpy	Light pitting, scattered deep pits
316 Stainless Steel	Bottom	1 mpy	Incipient pitting
	10′	<1 mpy	Incipient pitting
	20′	<1 mpy	Incipient pitting
	30′	<1 mpy	Incipient pitting
Hastelloy B	Bottom	1 mpy	Pitting, intergranular attack, concentration cell attack
	10′	2 mpy	Pitting, intergranular attack, concentration cell attack
	20′	1 mpy	Pitting, intergranular attack, concentration cell attack
	30′	2 mpy	Pitting, intergranular attack, concentration cell attack

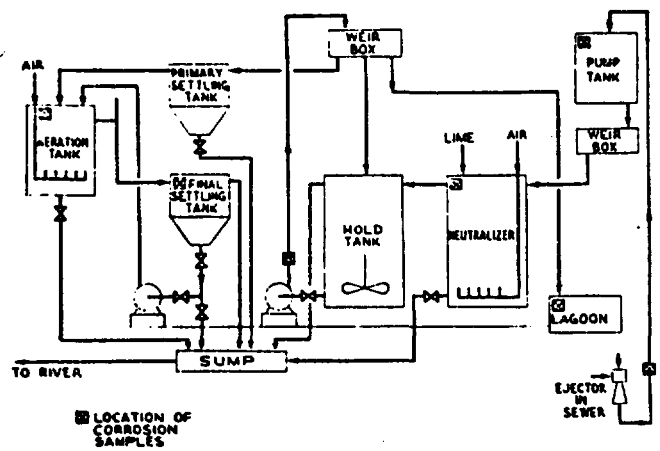

Figure 5—Flow diagram of waste treatment pilot plant.

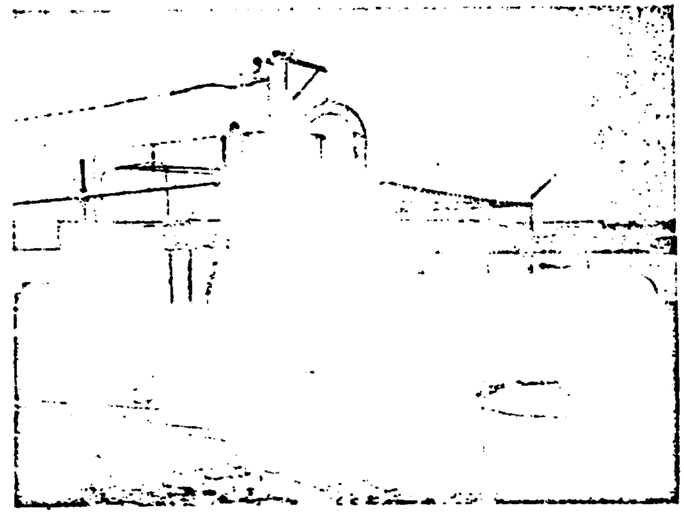

Figure 6—Raw waste, lifted from the sewer by a hydraulic ejector in the standpipe (right foreground), is discharged into the pump tank (upper center).

TABLE 2 (CONTINUED)—Results of Corrosion Tests in Main Sewer Pipe and 37 Feet Standpipe After 1819 Hours Exposure[a, b]

Sample Identification	Location of Sample In Standpipe	Average Corrosion Rate	Remarks
Nickel	Bottom	<1 mpy	Light pitting, scattered deep pits
	10'	2 mpy	Light pitting, scattered deep pits
	20'	1 mpy	Light pitting, scattered deep pits
	30'	2 mpy	Light pitting, scattered deep pits
Monel	Bottom	<1 mpy	Light pitting, concentration cell
	10'	1 mpy	Severe cratering
	20'	<1 mpy	Light pitting, concentration cell
	30'	<1 mpy	Severe pitting, intergranular attack
Polyvinyl Chloride, Type II	Bottom	+ 0.3 P.C.W.[c]	Softened, warped, absorbed odors
	10'	+ 0.004 "	Warped, absorbed odors
	20'	+ 0.07 "	Warped, absorbed odors
	30'	+ 0.027 "	Warped, absorbed odors
Polyvinylidene Chloride	Bottom	+ 0.26 "	Softened, warped, absorbed odors
	10'	+ 0.08 "	Softened, warped, absorbed odors
	20'	+ 0.03 "	Softened, warped, absorbed odors
	30'	— 0.01 "	Softened, warped, absorbed odors
Acrylonitrile Butadiene Copolymer	Bottom	— 0.41 "	Softened, warped, absorbed odors
	[illegible]	+ 0.3 "	Softened, absorbed odors
	30'	— 0.2 "	Absorbed odors, no degradation
Neoprene	Bottom	+30 "	Jellied mass material
	10'	+14.6 "	Softened, swelled, sticky, absorbed
	20'	+ 2.7 "	Distorted, absorbed odors
	30'	— 0.01 "	Slight swelling, absorbed odors
Chlorosulfonated polyethylene	Bottom	+35 "	Softened, swelled, absorbed material
	10'	+13.4 "	Softened, swelled, absorbed material
	20'	+ 3.5 "	Softened, absorbed odors
	30'	+ 0.003 "	Absorbed odors
Red Rubber	Bottom	+41 "	Softened, swelled, absorbed material
	10'	+13 "	Softened, swelled, absorbed material
	20'	+ 5 "	Softened, swelled, absorbed material
	30'	+ 0.2 "	Absorbed odors
Polyethylene	Bottom	+ 7.2 "	Sticky, darkened, absorbed odors
	10'	+ 7.4 "	Darkened, absorbed odors
	20'	+ 4.3 "	Darkened, absorbed odors
	30'	+ 0.01 "	Darkened, absorbed odors
Polytetrafluoro Ethylene	Bottom	....	Absorbed odors
Pine (Phenolic Treated)	Bottom	+ 0.5 "	Absorbed material, leaching of soft wood
	10'	+ 1.8 "	Absorbed material, leaching of soft wood
	20'	+ 1.8 "	Absorbed material, leaching of soft wood
	30'	— 1.4 "	Absorbed odors, bleached
Pine (Furan Treated)	Bottom	— 0.6 "	Absorbed material, leaching of soft wood
	10'	+ 1.1 "	Absorbed material, leaching of soft wood
	20'	+ 1.2 "	Absorbed odors, surface cracking
	30'	— 1.2 "	Absorbed odors, bleached

(a) Liquid level in standpipe (river stage) during test averaged 14 foot-20 foot above 4 foot diameter sewer pipe.
(b) Surface of liquid in standpipe covered by an oil layer.
(c) Percent change by weight.

treatment plant effluents. Oxygen is absorbed at the surface from the atmosphere and also results photosynthetically from plankton or algae.[4] Considerable land area is needed because ponds must be shallow and require retention up to 90 days to react. During this time some solids settle, some liquid may be absorbed into the ground and additional purification could come from spontaneous chemical reactions in the wastes.

Aerobic biological treatment is sensitive to poisoning by germicides and heavy metals. Both toxic materials are present in the Monsanto village sewage but experience has shown that the wastes can be treated successfully. Further information is available in other reports.[5, 6, 7, 8]

The activated sludge pilot plant used by the author's company is shown in Figure 3. The associated oxidation lagoon is pictured in Figure 4. Figure 5 shows the flow sheet of the complete system. The waste was pumped from the sewer at a point near the river, to a pump tank shown in Figure 6 (a pump off this tank supplied the power to an ejector located in the bottom of a 37 foot deep sewer standpipe). The waste drained through a stainless steel weir box which controlled the overflow to a 2000 gallon wooden neutralizer tank. The waste was neutralized with lime, preaerated, overflowed to a 2000 gallon agitated wooden hold tank and the wastes were blended, (see Figure 7). This material was pumped to a second stainless steel weir box, which controlled the overflow to both a primary settling tank of steel, 3 ft. diameter, and to the lagoon, one tenth acre in size and three feet deep, shown in Figure 4. From the primary settling tank the effluent flowed by gravity to an aeration tank of steel, 6 feet x 6 feet, shown in Figure 8. Later the material overflowed to a final settler, again a 3 ft. diameter steel tank where the biological solids were removed and pumped back to the aeration tank for seed. The purifier effluent

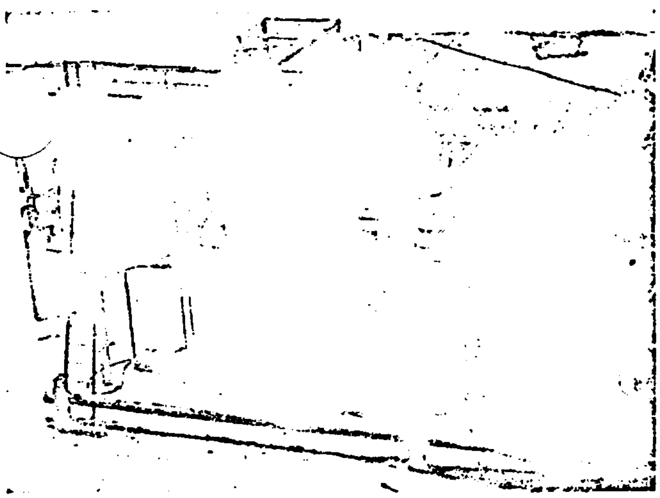

Figure 7—Neutralizer/pre-aeration tank (far right). Hold tank is second from right.

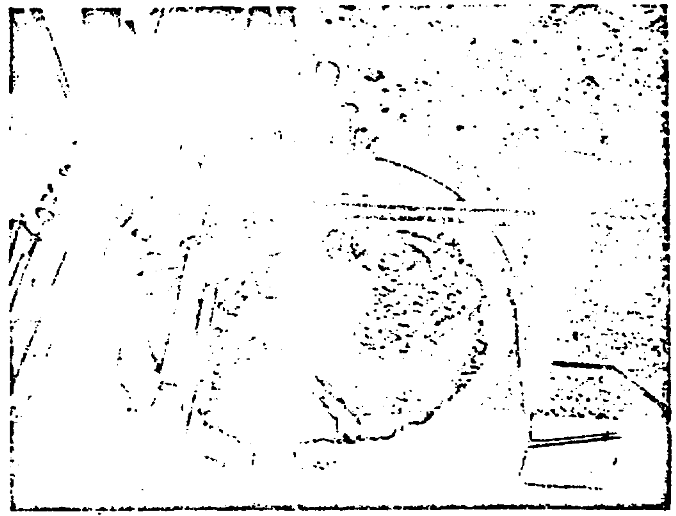

Figure 8—Top view of aeration tank.

overflowed from the settling tank to the river.

One full scale secondary waste treatment plant has been built from data secured from pilot plant studies. This unit, at the Monsanto plant at Anniston, Alabama, is responding to the performance anticipated from the pilot plant studies.[1, 9]

Experimental Procedure

Metallic corrosion specimens were prepared from commercial sheet stock, saw oversize and then machined to a final size of ¼ inch x 1 inch x 2 inches with a ⅜-inch diameter support drilled near one end. Sensitized specimens were made by welding two sheets together, the weld being the longer axis of the completed coupon. All samples were polished to a 120 grit finish and hand stamped for identification.

The size of non-metallic corrosion specimens were 2-3 times the 5.5 square inch area of the metal coupons. They were exposed in an "as-received" condition.

All specimens, except concrete, were electrically insulated and separated from each other and from their support holders by the use of machined fluorocarbon sleeves, washers and spacers. Concrete samples were set in the bottom of the exposure.

Coupon exposures were made in the

TABLE 3—Results of Corrosion Tests In and Above Main Effluent Sluice, Pumping Station, 3096 Hours Exposure[a]

Sample Identification	Location of Sample	Average Corrosion Rate, mpy	Remarks
Gray Cast Iron	Liquid Vapor[b]	26.4 23.8	Pitting Pitting
Ni Resist I	Liquid Vapor	1.9 5.3	
Ni Resist D II	Liquid Vapor	3.2 8.9	Pitting
90/10 Cu-Ni	Liquid Vapor	<0.1 0.1	Profuse incipient pitting Profuse incipient pitting
Bronze, Commercial	Liquid Vapor	0.5 1.6	Slight concentration cell attack Pitting
Bronze, 10% Al-5% Ni	Liquid Vapor	5.5 1.9	Incipient pitting
Bronze, Ni Vee Type A	Liquid Vapor	0.6 2.2	Slight concentration cell attack
Bronze, Ni Vee Type B	Liquid Vapor	0.7 2.5	Slight concentration cell attack Pitting
Monel	Liquid Vapor	0.3 2.2	Incipient pitting Pitting
Ni-O-nel	Liquid Vapor	<0.1 <0.1	
304 Stainless Steel	Liquid Vapor	<0.1 0.1	Pitting; crevice attack Pitting; incipient crevice attack
316 Stainless Steel	Liquid Vapor	<0.1 <0.1	
Durimet 20	Liquid Vapor	<0.1 <0.1	

[a] Joint test with International Nickel Co. for U.S. Engineers, St. Louis District; Evaluations by A. J. Marron, Inco.
[b] Vapor exposure, in atmosphere, 2 feet above liquid effluent.

TABLE 4—Results of Corrosion Tests in Liquid and at Interface[a] of Pilot Plant Pump Tank (1416 Hours Exposure)

Sample Identification	Location of Sample	Average Corrosion Rate	Remarks (Examination at 1X, 5X, 40X)
Steel	Liquid Interface	24 mpy 39 mpy	Severe pitting and conc. cell attack Severe pitting and conc. cell attack
304 W Stainless Steel [b]	Liquid Interface	<1 mpy <1 mpy	Severe conc. cell attack Severe conc. cell attack
316 W Stainless Steel	Liquid Interface	....	No attack No attack
Carpenter 20 W	Liquid Interface	....	No attack No attack
[illegible]ze, ASTMB 144 Lead/Tin	Liquid	1 mpy	Uniform shallow pitting
[illegible]er, modified carbon filled, glass fiber reinforced	Liquid Interface	+0.02 Weight Percent Change +0.09 Weight Percent Change	No attack No attack
Concrete, air entrained, 3000 psi (min)	Liquid	....	Severe attack on cement

[a] Samples exposed at liquid/vapor interface.
[b] W designates welded sample.

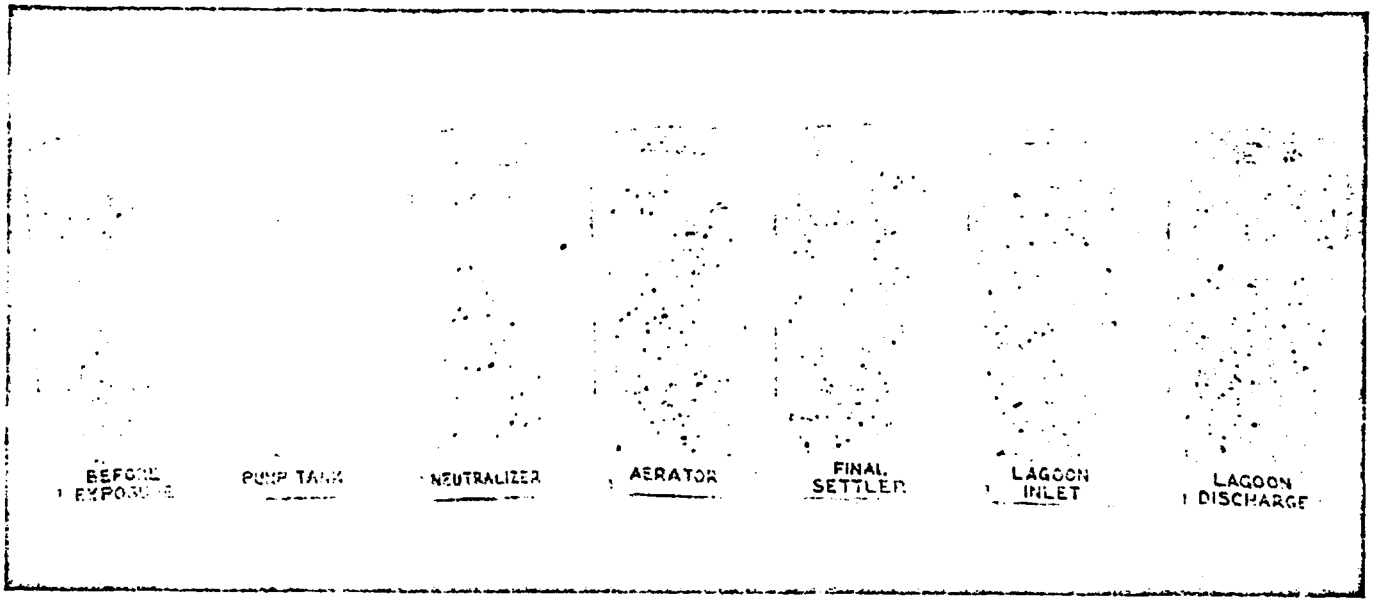

Figure 9—Concrete before and after exposure in pump tank, neutralizer, aeration, final settler and lagoon.

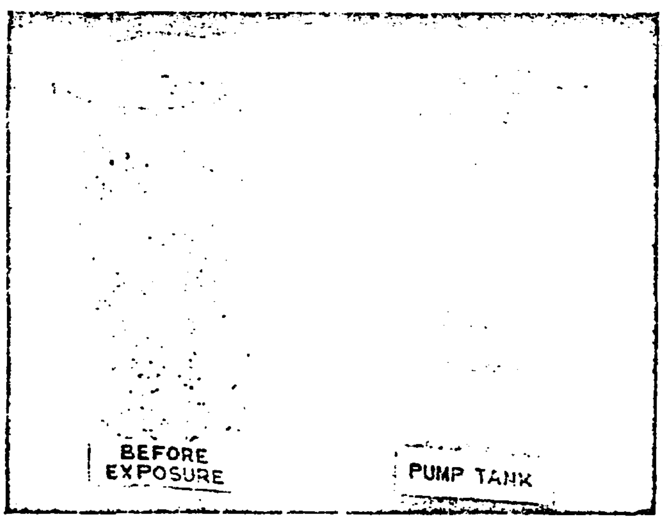

Figure 10—Concrete before and after exposure in pump tank. Note damage.

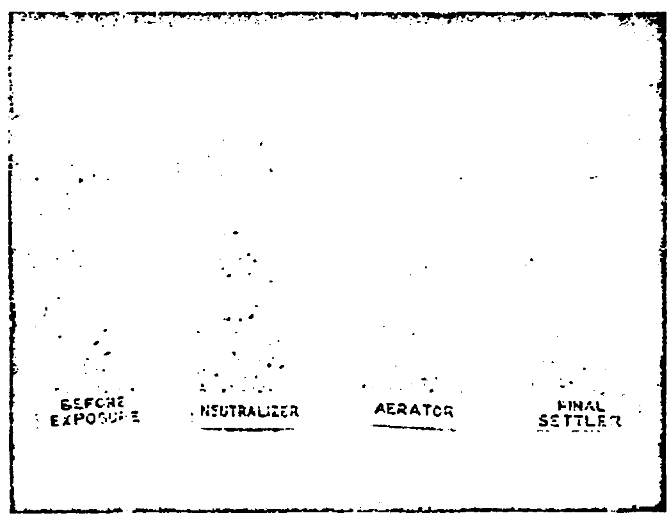

Figure 11—Concrete before and after exposure in neutralizer, aerator and final settler.

TABLE 5—Results of Corrosion Tests in Liquid and at Interface[a] of Pilot Plant Neutralizer,[b] 1488 Hours Exposure

Sample	Location	Rate	Remarks
Steel	Liquid Interface	56 mpy 1 mpy	Severe pitting and concentration cell Light pitting, locally moderate
304 W Stainless Steel[c]	Liquid Interface	<1 mpy <1 mpy	No attack No attack
316 W Stainless Steel	Liquid Interface	<1 mpy <1 mpy	No attack No attack
Bronze, ASTMB 144 Lead/Tin	Liquid Interface	<1 mpy <1 mpy	General shallow pits General tiny pits
Yellow Pine (Phenolic treated)	Liquid Interface	+ 9.45 Weight Percent Change +10.98 Weight Percent Change	Absorbed material, leaching of soft wood Absorbed, some splitting
Yellow Pine (Furan treated)	Liquid Interface	+16.55 Weight Percent Change +19.24 Weight Percent Change	Absorbed material Absorbed material
Redwood	Liquid Interface	+ 6.38 Weight Percent Change + 5.15 Weight Percent Change	Bleached, absorbed material Bleached, absorbed material
Concrete, air entrained, 3000 psi (min)	Liquid	....	No attack

(a) Samples exposed at liquid/vapor interface.
(b) Agitated with 2 turbine impellers at 90 RPM, 2 diagonally vertical baffles in tank.
(c) W designates welded sample.

pilot plant at eight test stations, locations shown on Figure 5. Samples were tested in the pilot plant and lagoon from 1409 to 3096 hours; two coupons were posed in the lagoon for only 406 hours.

After exposure, the metallic samples were cleaned of wastes, and products of corrosion, washed with detergent and acetone, dried and weighed. Corrosion rates were calculated from weight loss.

All coupons were examined with the naked eye for obvious defects and studied under the microscope at 5X and 40X. Plastic and wood samples were washed with warm water, dried with absorbent paper/cloth and weighed before they could dry out. These samples were again examined after they were dried to a constant weight. Concrete samples were washed and examined.

TABLE 6—Results of Corrosion Tests in Discharge Pipe Line from Hold Tank Discharge Pump, 1409 Hours Exposure[a]

Sample Identification	Average Corrosion Rate, mpy	Remarks (Examination at 1X, 5X, 40X)
Steel	21	Severe pitting, moderate concentration cell
304 W Stainless Steel[b]	<1	Slight concentration cell
316 W Stainless Steel	<1	No attack
Carpenter 20	...	No attack
Bronze, Lead/Tin ASTMB 144	2	Gross shallow pitting, moderate concentration ce l

[a] Pump discharged at 30 gpm, 5.2 fps pipe line flow over samples.
[b] W designates welded samples.

Results and Discussion

Results of all corrosion tests are tabulated in Tables 2 through 9. Corrosion rates and types of corrosion are reported. These latter observations can be controlled over the corrosion rates, *per se*. At the same time, it is no more reasonable to say that only those materials showing uniform attack can be considered for engineering application than it is to accept only those with low corrosion rates. Consider the following example. Type 304 stainless steel suffered less than a mil penetration per year in every exposure series, yet in only the neutralizer tank, Table 5, was the material without pitting or concentration cell damage. Though a material may be known to have excellent resistance, as Type 316 stainless steel, a material having a higher corrosion rate may be more economically suitable for tank construction.

The before and after condition of concrete tested in the pump tank, neutralizer, aeration, final settler and lagoon are shown in Figures 9, 10 and 11.

TABLE 7—Results of Corrosion Tests in Liquid and at Interface[a] at Pilot Plant Aeration Tank, 1488 Hours Exposure

Sample Identification	Location of Sample	Average Corrosion Rate	Remarks (Examination at 1X, 5X, 40X)
Steel	Liquid Interface	62 mpy 4 mpy	Uniform loss plus pitting Severe pitting and concentration cell
W Stainless Steel[b]	Liquid Interface	<1 mpy <1 mpy	Destructive concentration cell No attack
16 W Stainless Steel	Liquid Interface	<1 mpy <1 mpy	No attack No attack
Bronze ASTMB 144 Lead/Tin	Liquid Interface	1 mpy 1 mpy	Shallow pitting Shallow pitting
Yellow Pine (Phenolic treated)	Liquid Interface	10.8 Weight Percent Change 8.9 Weight Percent Change	Absorbed material, some splitting Absorbed material
Yellow Pine (Furan treated)	Liquid Interface	17.31 Weight Percent Change 13.05 Weight Percent Change	Absorbed material, some splitting Absorbed material
Redwood	Liquid Interface	5.08 Weight Percent Change 5.16 Weight Percent Change	Grey, absorbed material, split Grey, absorbed material, split
Concrete, air entrained, 3000 psi (min)	Liquid	...	No attack

[a] Sample exposed at liquid/vapor interface.
[b] W designates welded sample.

TABLE 8—Results of Corrosion Tests in Liquid and at Interface[a] of Pilot Plant Final Settler Tank, 1563 Hours Exposure

Sample Identification	Location of Sample	Average Corrosion Rate	Remarks (Examination at 1X, 5X, 40X)
Steel	Liquid Interface	4 mpy 3 mpy	Pitting, severe concentration cell Deep pits, concentration cell
304 W Stainless Steel[b]	Liquid Interface	<1 mpy <1 mpy	Severe concentration cell Severe concentration cell
316 W Stainless Steel	Liquid Interface	<1 mpy <1 mpy	No attack Several isolated deep pits
Bronze, ASTMB 144 Lead/Tin	Liquid Interface	<1 mpy <1 mpy	General General
Yellow Pine (Phenolic treated)	Liquid Interface	8.87 Percent Weight Change 10.04 Percent Weight Change	Bleached, absorbed material, leached soft wood Bleached, absorbed material, leached soft wood
Yellow Pine (Furan treated)	Liquid Interface	18.97 Percent Weight Change 10.61 Percent Weight Change	Same as phenolic treated + splitting Same as phenolic treated + splitting
wood	Liquid Interface	5.29 Percent Weight Change 9.05 Percent Weight Change	Same as phenolic treated pine Same as phenolic treated pine
Concrete, air entrained, 3000 psi (min)	Liquid	...	No attack

[a] Sample exposed at liquid/vapor interface.
[b] W designates welded specimen.

Conclusion

An activated sludge waste treatment plant can be built of economical,[10] commercially available construction materials. Table 10 lists acceptable materials for equipment, pipe and fittings for each unit operation of the biological treatment facility. While some specific selections will vary from one industrial waste treatment installation to another, the environment reported in this test is composite enough to allow most of the results to be accepted as a guide for design.

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TABLE 9—Results of Corrosion Tests in the Inlet to and Discharge from the Pilot Plant Lagoon, Liquid Exposure

Sample Identification	Sample Location	Exposure Time (Hrs.)	Percent Weight Change	Remarks (Examination at 1X, 5X)
Polyester, modified carbon filled, glass fiber reinforced	Inlet Outlet	406 406	+0.04 +0.13	No attack No attack
Concrete, air entrained, 3000 psi (min)	Inlet Outlet	1261 1261	....	No attack No attack

TABLE 10—Recommended Materials of Construction for All Unit Operations of an Activated Sludge Waste Treatment Plant*

	EQUIPMENT**				
Unit Operation	Piping	Valves	Pumps	Tanks	Basin
Raw sewage	A, B, F, G, I	A, B, C, D, E, I, L	A, B, C, D, E, L	A, B, F, G, I	F
Neutralizer Hold tank Primary Settler	A, B, G, H, J, K	A, B, C, J	A, B, C, J	A, G, H, K	H
Aeration tank Final Settler	A, G, H, K	A, C	A, C	A, G, H, K	H
Lagoon	....	....	....	....	F, H

* These data summarize the results shown in Tables 2 through 9.

** Types of Material:
A — 316 Stainless Steel
B — Alloy 20 Stainless Steel
C — B 144 Bronze
D — Ni Vee Bronze
E — Ni Resist I
F — Polyester, modified
G — Pine, treated
H — Concrete
I — Fluorocarbon
J — 304 Stainless Steel
K — Redwood
L — Ni-O-nel

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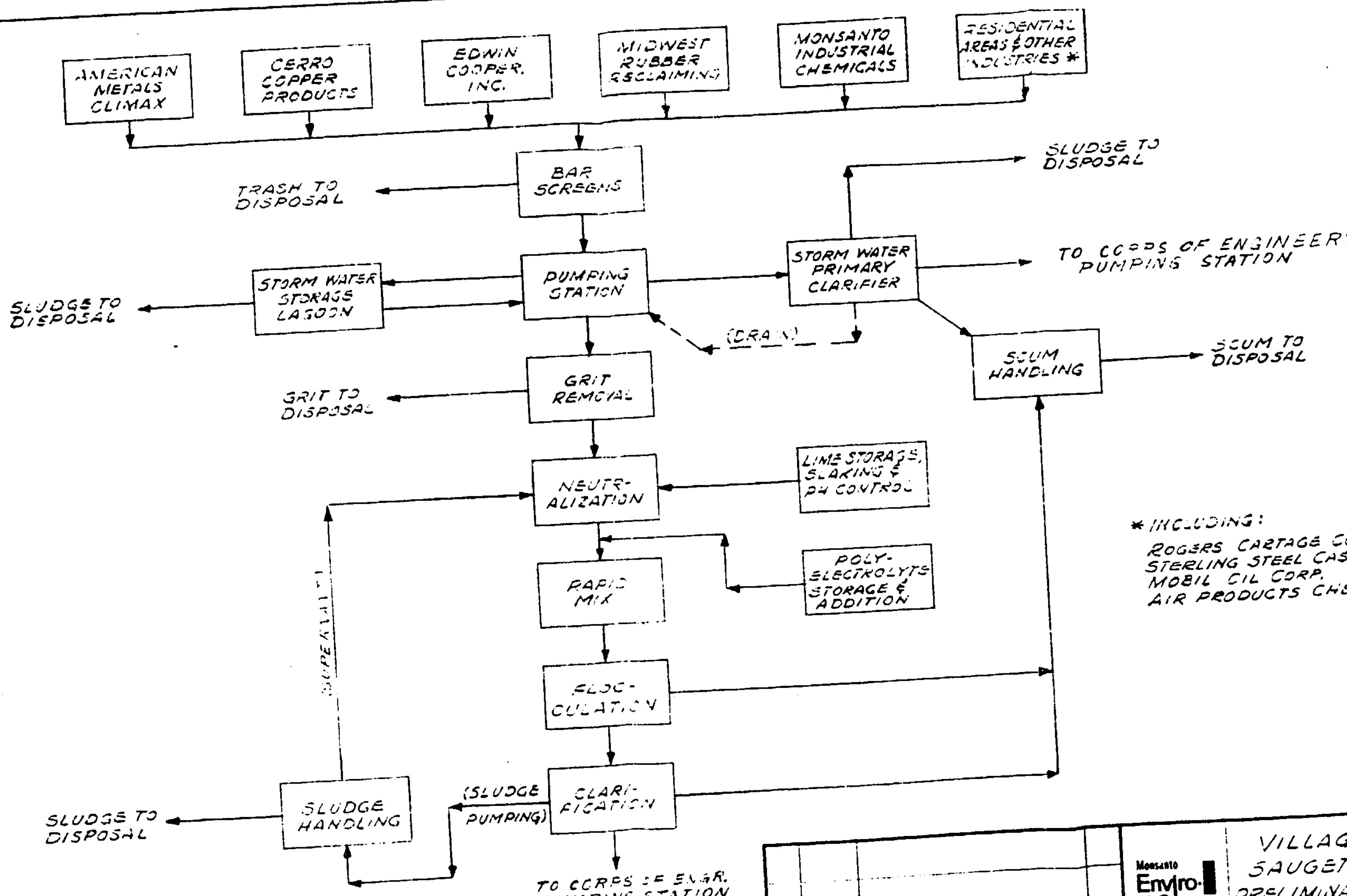

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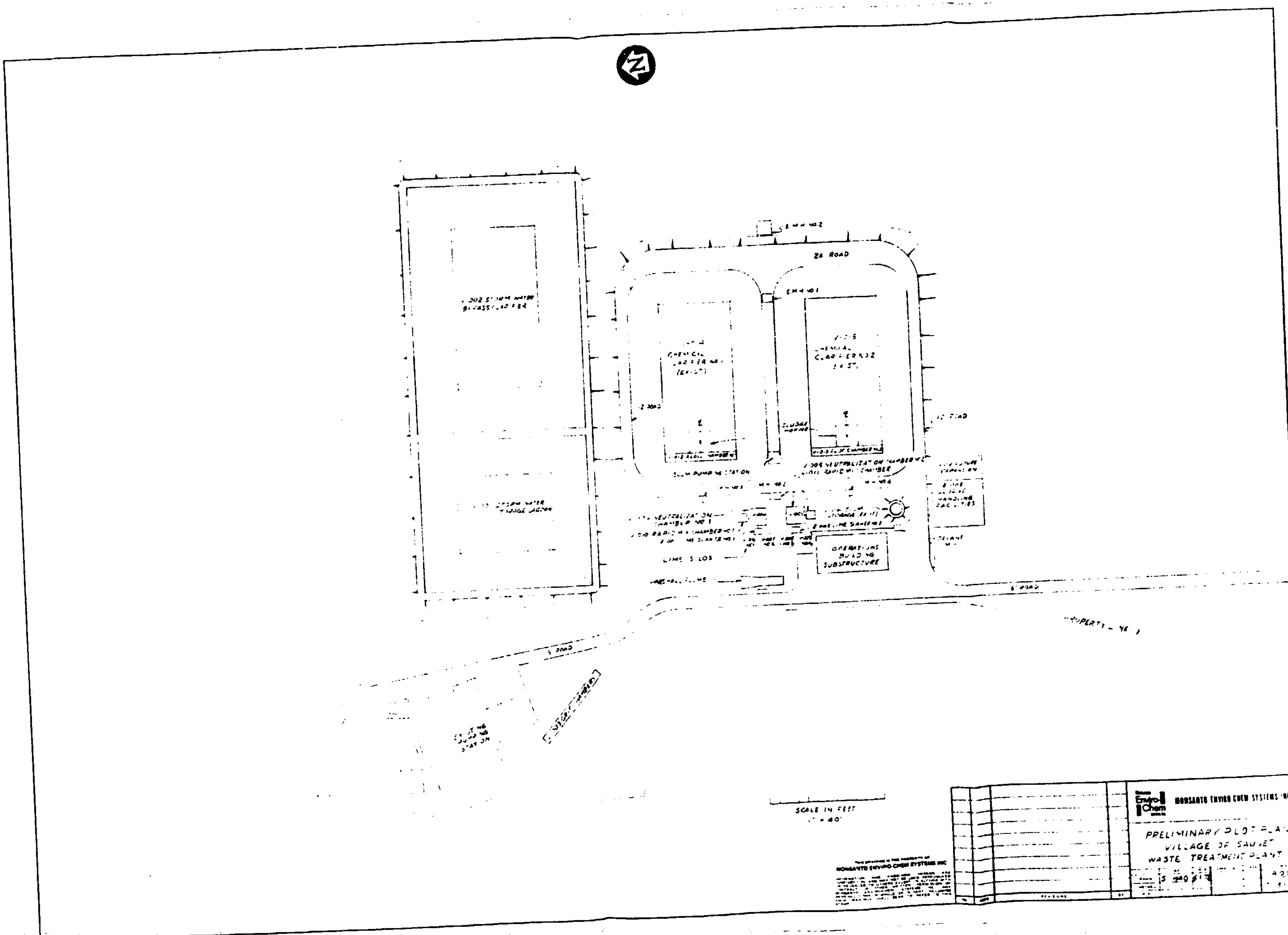
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